

# Metallurgical & Chemical Engineering

Volume XII, Number 11

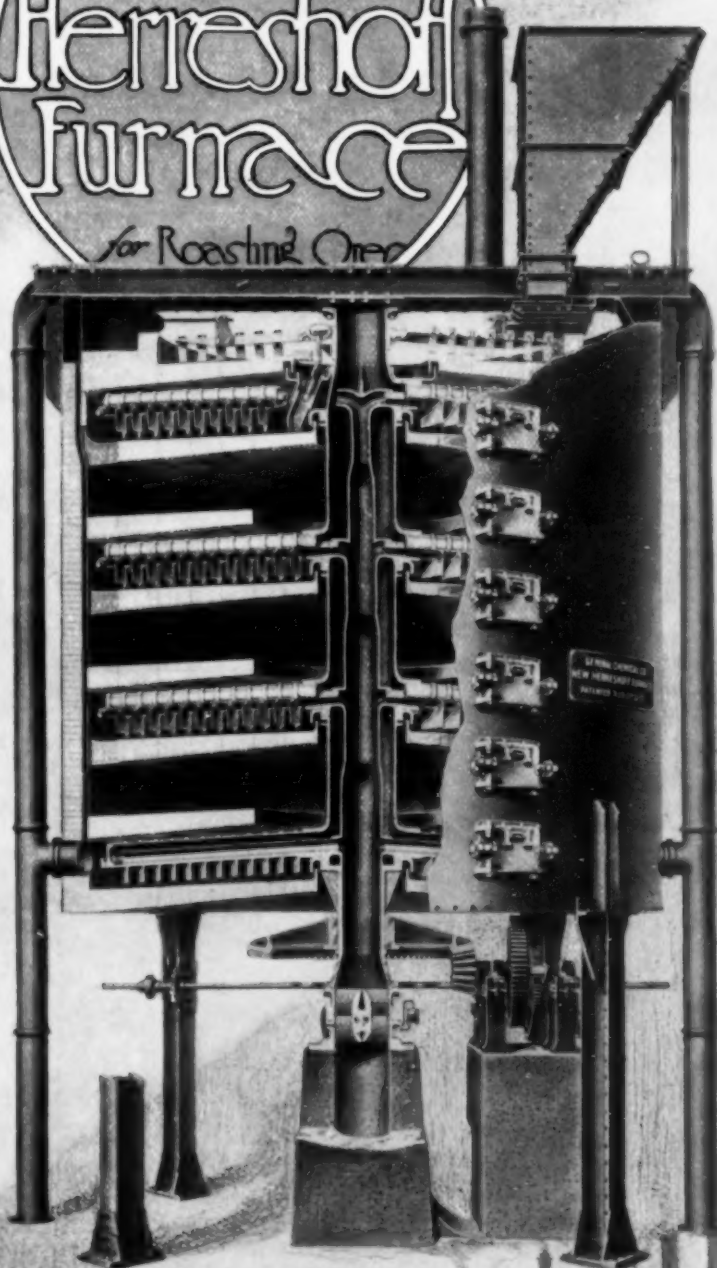
November, 1914

McGraw Publishing Co., Inc.

Temperature  
Controlled  
Furnaces built  
in various sizes  
for Chemical  
and Metallurgical  
Work. We solicit  
inquiries in regard  
to your Roasting  
Problems.

Catalogue sent on application

The New  
Herreshoff  
Furnace  
for Roasting Ore



Gene J. Chemical Company  
New York, N.Y.

Pacific Foundry Company San Francisco, Cal. Agents

## Reason No. 3 For Shriver Filter Press Efficiency

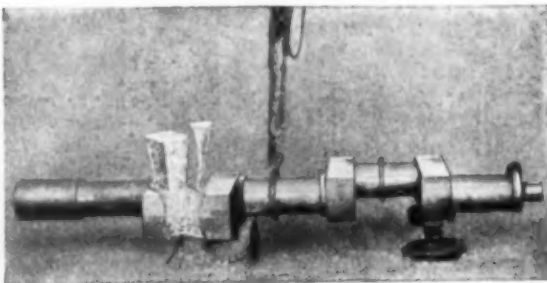
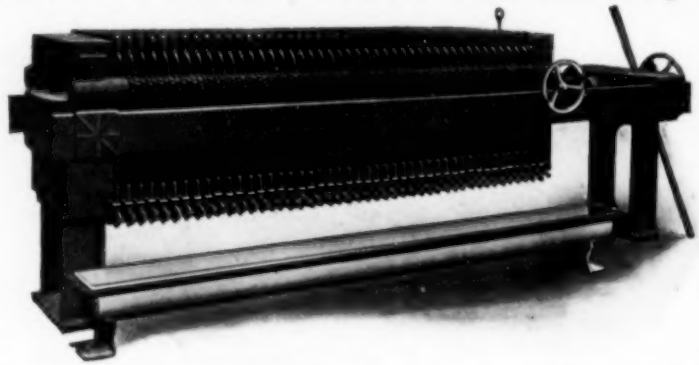
### From Pig Iron to Finished Press

every step is carried on in this one shop of Filter Press Specialists. The casting of the metal, the proportioning of the mixture to assure Shriver strength, the machining to template to assure Shriver Accuracy, and the final assembling and testing to make sure that no detail that goes to make up Shriver Quality is lacking—all is done in one big plant under the personal supervision of men whose life-long business has been building filter presses. You cannot afford to overlook SHRIVER PRESSES: look them over instead.

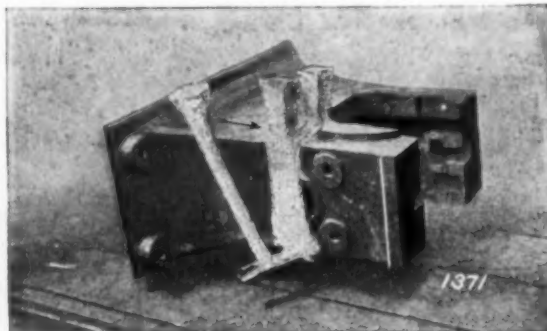
**T. SHRIVER & CO.**

808 Hamilton St., Harrison, N. J.

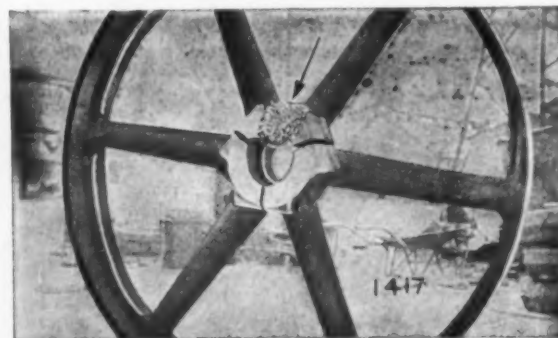
6932



9/4 inch Crankshaft Welded in 49 hours with Thermit.



Thermit Weld on Cast Iron Pillow Block Before Machining.



Thermit Weld on Hub of Cast Iron Pulley.

## In Case of A Breakdown Wire our Nearest Office

We weld broken crankshafts, flywheels, spokes, gear wheels, connecting rods and many other sections in quickest time and at least cost.

We give you a PERMANENT repair at very little more than a patch and at a great saving over purchasing a new part.

Repairs executed at either your shops or ours. We undertake work at a moment's notice. **All work guaranteed.**

Don't wait for a breakdown to occur, but write today for full information regarding the Thermit Process of Welding.

Remember the old proverb:

**"FOREWARNED, FOREARMED."**

Obtain our Pamphlet No. 2941 for your reference files.



**Goldschmidt Thermit Company**

Wm. C. Cuntz, Gen. Mgr.

90 West Street, New York City

329-333 Folsom St., San Francisco

7300 So. Chicago Ave., Chicago

103 Richmond St. W., Toronto, Ont.

# Metallurgical and Chemical Engineering

A Consolidation of ELECTROCHEMICAL AND METALLURGICAL INDUSTRY and IRON AND STEEL MAGAZINE

VOL. XII

NEW YORK, NOVEMBER, 1914

No. 11

PUBLISHED MONTHLY BY THE

McGraw Publishing Company, Inc.

JAMES H. MCGRAW, President.

Secretaryship vacant.

JOHN T. DEMOTT, Treasurer.

239 West 39th Street, New York.

TELEPHONE CALL, 4700 BRYANT.

CABLE ADDRESS, METCHEM, NEW YORK.

ROCKY MOUNTAIN OFFICE.....421 Boston Bldg., Denver, Colo.  
PACIFIC COAST OFFICE.....502 Rialto Bldg., San Francisco, Cal.  
CHICAGO OFFICE.....Old Colony Building  
PHILADELPHIA OFFICE.....Real Estate Trust Building  
LONDON OFFICE.....Hastings House, Norfolk St., Strand

E. F. ROEBER, Ph.D., Editor.

H. C. PARMELEE, Western Editor.

J. M. MUIR, Manager.

Yearly subscription price for United States, Mexico and United States dependencies, \$2.00; for all other countries, \$2.50. (European exchange, 10 shillings, 10 marks, 12.50 francs.)

Copyright, 1914, by the McGraw Publishing Company, Inc.

Entered as Second-Class Matter at the Post Office at New York, N. Y., under the Act of Congress, March 3, 1879.

NEW YORK, NOVEMBER, 1914

## EDITORIAL:

"Chemistry in America".....	669
Progress in Fume Recovery.....	670
Opportunity for Metallurgical Development Due to the War .....	670
The Steel Corporation Dissolution Suit.....	671

## READERS' VIEWS AND COMMENTS:

Fire Brick. By Charles S. Reed and J. E. Johnson, Jr. .	672
Grinding Ore for Cyanidation: A Suggested Modification for All-Sliming Practice. By J. V. N. Dorr.....	672
Is There a Complex-Ore Problem? By W. Motherwell and S. A. Ionides .....	673
True Chemical Energies of Combination. By Oscar Brophy .....	674
Cyanide Practice in the Porcupine District. By H. C. Parmelee and H. W. Hardinge.....	674
THE NON-FERROUS METAL MARKET.....	674
THE IRON AND STEEL MARKET.....	675
THE WESTERN METALLURGICAL FIELD.....	676
Chemistry at the American Gas Institute.....	677
Coal Tar Colors in America. By I. F. Stone.....	679
The Situation in the Chemical and Dyestuff Industry.....	684
Chemistry in Lighting.....	684
The Gas from Blast Furnaces, Its Cleaning and Utilization. By J. E. Johnson, Jr.....	685
Quantitative Blowpiping as an Aid to the Prospector. By Siegfried Fischer, Jr.....	693
Coal Gas Residuals. By Fred. H. Wagner.....	696
Niagara Falls Meeting of the American Electrochemical Society. (Report of Proceedings and Abstracts of Papers and Discussions).....	703
The Hall Process of Desulphurization. By H. F. Wierum....	718
Chemical Resources of California. By Samuel H. Dolbear..	720
The Evaporation and the Power Problem in Electrochemical Plants. By Otto Mantius.....	722
NOTES ON CHEMISTRY AND METALLURGY IN GREAT BRITAIN....	724
RECENT CHEMICAL AND METALLURGICAL PATENTS.....	725
The Electric Crane in the Electrolytic Copper Refinery.....	729
Colorizing .....	730
Present Status of the Fink Furnace.....	731
Gas Blowing Engines .....	734
Rapid Cyanidation of Ore.....	734
Obituary: C. E. Whittlesey and T. J. Grier.....	734
PERSONAL .....	735
DIGEST OF ELECTROCHEMICAL U. S. PATENTS.....	736
BOOK REVIEW .....	736

## "Chemistry in America"

For a brilliant leadership of many years, for many a great advance in science, for many a word and many an act of wise counsel and hearty encouragement, the chemical profession of America is indebted to Edgar F. Smith, Blanchard professor of chemistry at the University of Pennsylvania and provost of this venerable American institution of learning. But no more delightful gift has ever been made by him to his fellow chemists than his recent book on "Chemistry in America." It is a charming book, this story of the early days of chemistry in Philadelphia—a charming story of strong individualities—Woodhouse, Priestley, Cooper, Silliman, and Robert Hare.

In this book we find the annual oration delivered before the Chemical Society of Philadelphia (the oldest chemical society in the world) on April 11, 1798, by Thomas P. Smith. From this address we quote the concluding sentences: "Living as we do in a new, extensive, and unexplored country, separated by an immense ocean from all other civilized nations, we must feel ourselves deeply interested in a knowledge of its mineral productions and this can only be arrived at through the medium of chemistry. As far as our very limited knowledge has yet gone, we have every reason to believe that nature has been far from bestowing her blessing upon it with a parsimonious hand. Abounding as it does with the richest ores of the most valuable metals, we should be committing a crime of the blackest dye, were we through wilful ignorance to trample under our feet these invaluable gifts of the Creator.

"The only true basis on which the independence of our country can rest are agriculture and manufactures. To the promotion of these nothing tends in a higher degree than chemistry. It is this science which teaches man how to correct the bad qualities of the land he cultivates by a proper application of the various species of manure, and it is by means of a knowledge of this science that he is enabled to pursue the metals through the various forms they put on in the earth, separate them from substances which render them useless, and at length manufacture them into the various forms for use and ornament in which we see them. If such are the effects of chemistry, how much should the wish for its promotion be excited in the breast of every American. It is to a general diffusion of a knowledge of this science, next to the virtue of our countrymen, that we are to look for the firm establishment of our independence."

These sentences are as fresh and as true to-day as they were 116 years ago. They raise the question as to the advance made in this period. What a grand and glorious advance has been made in one way, we appreci-

ate by considering simply the present status of American metallurgy in this country's life and in the world's work, while non-metallurgical chemistry has long outgrown agriculture and is conquering daily new fields and creating economic values. But there is another side to the picture. Does the average American—the average business man and the average professional man—grasp any more clearly now than in 1798 the fundamental importance of chemistry in our industrial life? Does the average American now grasp the idea of Smith that it is to a general diffusion of chemical knowledge that this country is to look for the firm establishment of its independence?

A few weeks ago these questions would have been answered truthfully in the negative. But the European war is doing wonders in driving some fundamental facts home to our greatly astonished fellow-citizens. A clearer understanding by the public of the functions of chemistry and of the chemist must be the result. There are innumerable industrial problems that must be solved and can be solved only by the chemist. For the American chemist the situation is full of opportunities—and responsibilities.

#### Progress in Fume Recovery

The tremendous amount of costly experimental work that has been done in the treatment of fume from pyrometallurgical operations is beginning to bear fruit commensurate with the preliminary outlay of time and money. Two phases of the problem have had to be considered: the abatement of nuisance arising from the discharge of noxious gases into the atmosphere, and the recovery of metallic waste. The latter is presented in practically every smelting works, regardless of location, and usually both must be solved. In the case of abating a nuisance, the additional problem is presented of making by-products of sufficient value to offset the cost of their recovery, so that if possible the net cost of operation shall not be increased.

A review of the progress that has been made in smelter-fume treatment indicates that the elimination of sulphur dioxide still awaits the commercially demonstrated successful process. Solid constituents of furnace gases can be settled in flues, collected in bags or precipitated electrically by the Cottrell process. Sulphuric acid can be neutralized with metallic oxides, usually zinc, and gathered in bags, or it can be collected also by electrical precipitation together with dust. But none of these methods affects the sulphur dioxide, which escapes to the atmosphere and causes more or less damage depending on the amount of natural or cultivated vegetation near the smelter.

A method of promise for the elimination of sulphur dioxide, and the recovery of elemental sulphur from ores and mattes, is that of Hall, described elsewhere in this issue. By this process the sulphur in sulphide ores is converted into a by-product of value. Sulphur dioxide in the stack gases is reduced to a negligible quantity, far below the amount permissible under the present terms of legal injunctions against smelters. Like other pioneer processes, this one has shown sufficient merit to

warrant further testing and experiment; but immediate extension of the work is prevented by the war.

Another possibility in the elimination of sulphur dioxide from furnace gases, which we understand is being investigated, is the use of di-calcium phosphate as an absorbent. It seems that some work by a German chemist suggests the possibility of using this chemical in a cyclic process in which sulphur dioxide might be absorbed at a comparatively low temperature, and later driven off at a higher temperature and condensed.

Returning to electrical precipitation, it is worth while to note some recent developments of importance: a change in the form of the precipitating apparatus, and the possibility of fractionally separating and precipitating the constituents of a furnace gas by varying the temperature.

The former type of treater consisted of metal plates with intermediate wires, the plates forming the collecting electrodes and the wires the discharge electrodes. The type adopted in one of the latest installations consists of iron pipes 5 in. in diameter and 10 ft. long forming the collecting electrodes, with discharge wires supported centrally in the pipes. This form of treater is proving satisfactory, and experiments are being made with pipes up to 18 in. or 20 in. in diameter to meet various conditions.

The discovery that fractional precipitation can be made by successively reducing the temperature of the gas, holds new possibilities; and while it is too early to announce results of this development, its importance will be appreciated when the complex composition of furnace gases is considered.

Still another interesting recent development in electrostatic precipitation is the process for detarring gas described in the American Gas Institute paper of Mr. F. W. Steere. As described elsewhere in this issue, the chief difference from the Cottrell process—and apparently a quite important one—is the use of alternating current instead of high-tension direct current.

#### Opportunity for Metallurgical Development Due to the War

While the domestic non-ferrous metal market continues generally dull on account of the war in Europe, there is evidence that in some instances an opportunity exists for new development in this country and a readjustment of the world's metal and mineral industry. We may cite three instances: tin, arsenic, and magnesite. European sources of these materials have played a large part in supplying our own demands, as a brief analysis of the statistics will show.

Among the world's nations the United States is reputed to be the largest consumer of tin. As a producer she is a negligible factor. The value of our tin imports in 1913 was over \$47,000,000; the quantity was about 40 per cent of the world's production. Our own output during the same period was 84 tons of 60 per cent concentrates, valued at about \$37,000. As we have no important tin deposits, our opportunity lies in the establishment of a tin-smelting industry to treat concentrates

that have been going to Europe for reduction. A supply is reasonably close at hand in Bolivia. That country sends annually to Europe concentrates containing 20,000 tons of metallic tin, which is only a fraction of our annual imports. With a dependable supply of ore and competent American metallurgists to design and operate reduction works, the remaining obstacle is a merchant marine to transport the ore.

The consumption of white arsenic in this country last year was roundly 7200 tons, of which we produced only about 2500 tons. The remainder was imported largely from European countries. Arsenic has been a troublesome element in the smelting industry, and while a considerable quantity has been recovered the output could be increased if there was a greater demand and prospect of better prices.

Domestic consumers of magnesite have been dependent mainly on foreign sources of supply. We imported last year 172,591 short tons and produced only 9632 tons. Since Austria-Hungary has supplied the major portion of our imports, the improbability of placing reliance on that source is apparent. Local supplies may be had in California, and although at some distance from Eastern markets, it may be possible to deliver this material cheaply on the Eastern seaboard via the Panama Canal. The Californian deposits are reported to be extensive and high-grade, and the time seems opportune for the advancement of this industry.

### The Steel Corporation Dissolution Suit

The case of the United States against the United States Steel Corporation is now before the judges, just three years after the suit was brought. In the past month the voluminous briefs have been filed and the oral arguments made, before the Circuit Court of Appeals at Philadelphia. There is left, however, an appeal to the United States Supreme Court, in case either party can find grounds for objecting to the decision now awaited, or in case the judges disagree.

While the briefs and arguments on either side deal principally with facts, or alleged facts, the case, of course, really hinges upon the law, and not indeed upon the strict letter of the law, as to how it should be interpreted, but upon how it should be applied. We are now more or less accustomed to seeing the courts decide "trust" cases and order various forms of dissolution, and it is well to point out that all such practices have been built up by the courts. The Sherman law says nothing about dissolutions. It prescribes for any person found guilty a fine not exceeding \$5,000, or imprisonment not exceeding one year, or both, and then prescribes that the term "persons" shall include corporations. In case a corporation formed by the purchase of separate units is determined illegal, the Sherman law gives the court no light or guidance other than the bare declaration that the thing is "illegal." It says nothing whatever about dissolutions, that procedure, as in the case of the Standard Oil and Tobacco companies, having been devised solely by the courts under the common law principle that where there is a wrong there must be

a remedy, hence the courts have been forced to devise a remedy.

The case of the Steel Corporation becomes peculiarly difficult, because the evidence, about the substantial truth of which there is practically no controversy, shows that the conduct has been progressively better and better. Indeed, the brief of the corporation counsel in substance admits that the consolidations prior to the formation of the Steel Corporation on April 1, 1901, such as the wire, tin plate and pipe mergers, were formed absolutely for the purpose of reducing competition, asserting indeed that such competition was proving ruinous and destructive. As to the conduct of the Steel Corporation itself, the government contentions are chiefly as to what occurred in the early rather than in the later years. Inasmuch as the law prescribes no punishment other than a fine not exceeding \$5,000, and imprisonment not exceeding one year, it does not seem that the corporation could be ordered dissolved as a means of punishment for what is passed, even if such punishment could be made to fall upon those guilty. If the court proceeds upon the basis of righting an existing wrong, then it is important to note that the wrongs shown in the testimony and referred to in the arguments, grew progressively less and less.

It is important to note that much has occurred in the steel trade during the three years since the suit was filed, and much that is favorable to the Steel Corporation. Many instances of good conduct were claimed by the Corporation, and admitted more or less by the government, and referring chiefly to the years immediately preceding the filing of the suit. In the three years since then a great deal more of the same character has been developed. There has been a still more open and competitive market. The average of prices has on the whole been lower. The condition of workmen has been improved still more. Indeed, of all the safety and welfare work done to date by far the major part has been done in the past three years. Exports reached a much higher level in 1912 and 1913 than in any previous year. It might be rejoined that possibly the United States Steel Corporation has been particularly "good" during the three years' progress of the suit, but that contention could hardly carry any weight in a court that had assumed the burden of finding a remedy for a discovered wrong; the court would naturally take the condition of the present. We assume that in an appeal to the Supreme Court, at any rate, means could be found for bringing the evidence up to date.

It is interesting to reflect how little interest is popularly manifested in the once famous steel suit. For several months prior to the bringing of the suit it was currently said in the steel trade that business was halting because the suit was impending, and it was predicted that if the suit were brought the steel trade could not become prosperous until it was settled, but the history is that less than a twelvemonth after the suit was brought the steel industry was operating at full capacity and prices were considerably advanced. The whole gamut up and down has been run once, and the steel suit is perhaps still far from its final adjudication.

## Readers' Views and Comments

### Firebrick

*To the Editor of Metallurgical & Chemical Engineering:*

SIR:—I am interested in an article in your August issue by Mr. J. E. Johnson, Jr., which relates to the firebrick business.

From his article I am led to believe that Mr. J. E. Johnson, Jr., is under the impression that the only purpose for which a firebrick is used is in a blast furnace, when he criticises firebrick manufacturers maintaining the standard size of a firebrick at 9 by 4½ by 2½. As a blast furnace is only one of many thousand places where firebrick are used, the manufacturer cannot follow the whim of the blast-furnace superintendent in maintaining his standards at the expense of all the other different users.

A brick smaller than the standard 9-in. square brick costs more to make, owing to loss in warpage and breakage in both the drying and the burning.

The standard sizes of firebrick as adopted by the Refractories Manufacturers' Association comprise all of the usual shapes and take a base price, this base price being determined by each manufacturer for himself. It costs more to make the unusual thing than it costs to make the usual thing. Therefore, based on cost, the firebrick manufacturer is entitled to more money, based on the 9-in. equivalent, when making those sizes which are larger than 9-in. standard.

Mr. Johnson states in his article that it is his opinion, the reason why the manufacturer charges about 20 per cent more for these unusual shapes than for the usual shapes, is "apparently that he needs it." I would ask if that is the reason why, when purchasing steel, a consumer pays a certain base price for one size and an extra over this base for another size. In this matter of "extras," I was very much interested in an address of a very prominent steel manufacturer given before the Iron and Steel Institute at their meeting last spring in Chicago, and I would suggest that Mr. Johnson refer to this address. It would be interesting to many of your readers to know Mr. Johnson's reasons of the necessity of these "extras" in the steel business.

CHARLES S. REED.

Chicago Retort & Fire Brick Co.,  
Ottawa, Ill.

\* \* \*

*To the Editor of Metallurgical & Chemical Engineering:*

SIR:—I am greatly obliged to Mr. Charles S. Reed for his communication on my treatment of the question of firebrick for furnace lining in your August issue, particularly for his comparison of the "extras" on firebrick with those on steel bars, as this comparison furnishes an excellent illustration of my point.

The shapes of which I spoke are the standard ones, Nos. 1 and 2 in keys 9 in. and No. 2 and 4 keys in 13½ in., and the "squares" or straights of those sizes, all of standard thickness, either 2¼ in. or 3 in. These are illustrated as the standard shapes in all the catalogs of firebrick that I have seen. But as I never have seen a catalog of the Reed blast-furnace brick, of course, I don't know whether these are standard with his company or not.

These may be compared with 1-in. and 1½-in. rounds and squares in steel bars.

Now if the price of the latter be made on 1-in. bars as a base knowing that it takes more labor or limits the output to roll a ¾-in. rod, we would naturally expect to pay more per ton for it, though we might be surprised if we had to pay the same price per foot.

This is analogous to the keys of the 9-in. brick; we can see that it costs more per ton to produce them than it does to produce 9-in. straights and the increased price per ton due to their taking the same price per piece is natural and does not arouse any protest that I have ever heard of.

Now let us turn to the case of 1½-in. bars; this is obviously similar to that of the 13½-in. brick. They require less labor and less overhead to produce than 1-in. bars. Do the steel makers say: "We are sorry but we are compelled to charge \$2.50 per ton 'extra' for these bars because they are hard to handle"—or could they carry out such a sales policy if they tried? Ask one and see what he says. Yet that is exactly similar to the policy of the brick manufacturers at which my comment was directed.

I believe that Mr. Reed's comparison thus expanded will make clear to him the anomaly in firebrick prices to which I alluded in my article and if Mr. Reed can now explain this anomaly in terms comprehensible to the blast-furnace man with his admitted ignorance of firebrick manufacture in most cases, he will confer a favor on me and, I believe, on many other furnace men.

J. E. JOHNSON, JR.

New York City.

### Grinding Ore for Cyanidation: A Suggested Modification for All-Sliming Practice

*To the Editor of Metallurgical & Chemical Engineering:*

SIR:—The general points made by Mr. Pentland, in his article in your October issue, are very well taken as to the necessity of a thorough investigation of the method to be used for treatment of a given ore, in order to provide the most efficient treatment for all portions of it.

I think it has been too common, in testing and in actual operation, to fail to recognize that reground sand is a different ore from the original slime formed from first grinding, although a screen test may eventually be the same on the two materials. I do not question what Mr. Pentland says regarding the necessity of longer agitation, and perhaps the use of a stronger solution, to make the economic recovery from the reground sand; although on the gold ores of the Black Hills, to which he refers in one place, we found that there was nothing gained by using either stronger solution or longer period of agitation on the fine sand, above that required for the slime.

The best method of giving the reground sandy material a separate treatment, providing that tests showed it to be profitable on the whole, is open to question. I would say that Mr. Pentland's proposal to agitate the partly ground material might require a greater total of agitating capacity than the method of agitating all the reground pulp together with the slime, after the first thickener. Where, however, one classifier is used for separating the tube-mill feed from the original slime, and other classifiers are used for removing the reground sand from the tube-mill discharge, his methods would be entirely feasible, except that unless the agitation were done at the dilution of the overflow of these secondary classifiers, it would seem that an additional thickener should be interposed between the classifier and the sand agitators.

In continuous agitation it is usually considered necessary to have at least three agitators in series in order to avoid short-circuiting. Consequently, with separate

agitation of the sand and slime pulps, this would mean that the total number of agitators in use would have to be doubled, except in very large plants where the time of agitation is so long that, in order to avoid too large units, more agitators are used than are necessary to avoid short-circuiting. It is well recognized, I think, that with all classes of agitators, and especially with the one I have developed, the cost per cubic foot of agitating capacity decreases with the increase in size of the unit used, so that the cost of three large agitators would be very much less than for six smaller ones. The operating cost for a large unit will also be less per cubic foot of capacity.

I cannot see where agitating the two products separately would affect concentration, as it would undoubtedly be the tube-mill discharge which would be concentrated. Mr. Pentland's suggestion of sending the slime formed from the concentrating tables directly to the thickener, while the sand that needed regrinding would be returned to the classifier, is perfectly proper, but I do not see that it has anything to do with the points made regarding agitation.

Mr. Pentland has discussed the question of our practice of precipitating only the solution from the first thickener, and not the solution from the thickeners following the agitators. Apparently he regards the circulation of this gold-bearing solution through the stamps or grinding apparatus, as likely to cause loss from leakage, etc. The point is well taken; but he has overlooked the fact that if you precipitate from the overflow of the thickener following the agitators, as well as the overflow of the first thickener, it will be necessary to precipitate a great deal more solution per ton of ore in order to have the same final loss, where continuous counter-current decantation is practiced. The cost of this additional precipitation is a very definite one which can be figured quite accurately in advance, and which I believe will greatly exceed the chances for loss in a well-constructed mill, by circulating a somewhat higher-grade solution. In my mind the limit of the value of the solution to be circulated depends upon the efficiency of precipitation, for very low-grade barren solution is essential in continuous decantation.

The Dorr agitator is well adapted for selective agitation, that is, for agitating the coarser or quicker-settling particles of ore a longer period than the finer particles in the same agitator in continuous work; but this would not necessarily allow the finer particles of sand to have a longer or different treatment from the equally slow-settling particles of slime. Mr. Pentland points out that the method he suggests may allow less mechanical loss of cyanide; but if he will note that in a normal flow in continuous counter-current decantation the battery solution coming from the first thickener goes directly to the zinc boxes and from there to the thickener next to the last, he will see that this is the solution the strength of which should be kept as low as possible.

To sum up I would say that if other considerations made it seem advisable to operate tube-mills and classifiers in closed circuit, it is not likely to pay to agitate the tube-mill return, containing partly ground material, separately from the final classifier overflow. If, on the other hand, a separate classifier is used for the reground material, and it can be operated at a dilution of, say, 3 to 1, which dilution is a satisfactory one for agitation, then the agitation of the reground sand might prove quite profitable. The point certainly deserves careful consideration in designing a mill, and Mr. Pentland is to be thanked for calling the attention of metallurgists to it.

J. V. N. DORR.

New York City.

### Is There a Complex-Ore Problem?

*To the Editor of Metallurgical & Chemical Engineering:*

SIR:—I agree with Mr. Skinner that in the United States so far the flotation process has only been a success on one-mineral separation, the reason being either that metallurgical knowledge is not sufficiently advanced to apply it to complex ores or that there are no payable ores that cannot be treated by ordinary mechanical means. But perhaps only capital is lacking.

I do not agree with Mr. Skinner that "everyone engaged in the metallurgical field is well aware of the work done in Australia." If he is correct, why has the United States been so backward in making use of the process?

Regarding my statement that "it might be worth while to have some experiments made with Colorado complex ores," he says "I already have the proof and he admits that he has not." What proof? Incidentally, I have admitted nothing. He then admits that he has recommended the flotation process "as a subsidiary to the other general operations" (in dealing with Colorado ores). How does he reconcile this with his previous statement that he does not know of any complex ore in Colorado that could possibly show any advantage under this (flotation) treatment?

He then goes on to say "our ores, as a rule, are rather coarsely crystalline so that it is not a difficult matter to make a proper separation by ordinary mechanical means." In other words, he admits that these so-called complex ores are not complex at all. I thought he was referring to ore that so far could not be treated at a profit, and my contention was that the flotation process might be applied profitably to that class of ore.

As Mr. Skinner is so fully cognizant of the work being done in Australia, he must surely know that "selective flotation" is only used on ore, slime or concentrate that is not amenable to ordinary concentration. In that case it would return a much greater, instead of (as he says) less profit to the mine than the "ordinary older means of mechanical separation." It certainly requires operating efficiency (as he says), but is not so expensive as he imagines.

Mr. Skinner's last paragraph is so vague that I am at a loss how to reply to it. If he will specify what proofs he requires against which statements of his, I shall endeavor to supply them. With which situation do I not even admit familiarity? After that there may be further argument.

W. MOTHERWELL.

Nacozari, Sonora, Mexico.

\* \* \*

*To the Editor of Metallurgical & Chemical Engineering:*

SIR:—Your September number containing Mr. W. Motherwell's comments on my contribution to "Is There a Complex Ore Problem?" has come to my attention.

His reference is to a quotation of mine about an ore containing 5 oz. of silver per ton, 14.5 per cent lead, 13 per cent zinc, and 0.25 per cent copper, and his assumption, from a similarity of composition, is that this ore was mined at Broken Hill, Australia; as a matter of fact, the ore came from Utah and contained, in addition to the above metals, a large percentage of pyrite which rendered it wholly unadapted to ordinary mechanical concentration. (The insoluble assayed 12 per cent to 13 per cent.) It is possible that this ore might give a fair separation with some flotation method, and I have heard that one already tried has been partly successful. If Mr. Motherwell or any other metallurgist has any solution for this problem, I should be very happy to forward his scheme of treatment or to put him in direct communication with the owner of this property.

In regard to his second comment, stating that the total extraction at the Broken Hill South mine during

	Tons	Metal Contents						Per Cent of Total		
		Pb %	Ag oz	Zn %	Pb Tons	Ag oz	Zn Tons	Pb	Ag	Zn
Feed	168,957	14.7	7.3	14.5	24,836	1,233,381	24,498	100	100	100
Lead cones	27,594	68.1	24.4	6.6	18,782	673,465	1,821	75.8	54.2	7.4
Zinc tailing	107,279	3.5	3.6	17.6	3,754	386,204	18,881	15.1	31.3	77.1
Quartz tailing	12,409	1.3	1.4	5.3	161	17,372	657	0.6	1.4	2.7
Slime	21,675	9.6	7.5	14.8	2,080	162,562	3,208	8.4	13.2	13.1

the second half of 1913, as quoted in the *Mining and Scientific Press*, was 91 per cent lead, 85.6 per cent silver and 84.2 per cent zinc: I have been at pains to find how this extraction was calculated. A fuller account and analysis of the half-yearly report is given in the *Australian Mining Standard* for March 15, 1914, page 186. From this it appears that four products are made: lead concentrate, zinc tailing (for delivery to the Amalgamated Zinc Company), quartz tailing (used as a filling underground), and a slime (stacked for future treatment).

The accompanying table shows the products obtained, the weight of metal produced in each case, and the percentage of total belonging to each class of concentrate. In the *Mining and Scientific Press* the extraction given was obtained by adding the percentages saved in the first two classes, and I believe you will agree with me when I state that this does not give a true result for the total extraction. In the lead concentrate there is 6.6 per cent zinc, amounting to 7.4 per cent of the total zinc in the ore, and while this is saved along with the lead, no credit is given for it in the commercial results; along with the zinc tailing is 3.5 per cent lead amounting to 15.1 per cent of the total lead in the ore, and for this it is exceedingly improbable that any credit would be given.

With regard to the extraction of zinc from this tailing, no figures are given but the credits received in selling the ore amount to from 85 cents to \$1.25 per ton, while the gross value of the ore sold to the Amalgamated Zinc Company, with lead at 4 cents per pound, silver at 50 cents per ounce, and zinc at 5 cents per pound would be \$22.20. These figures would indicate a commercial saving, which all will admit is the basis of successful mining, of approximately 5 per cent. The assumption that 100 per cent extraction is made from this product, therefore, is very far from being accurate, and Mr. Motherwell's citation is unfortunate and in error.

With regard to the slime product from a lead or copper ore being refractory, I am aware that there are several methods of making a low-grade concentrate from it. If Mr. Motherwell has any way of making a high-grade concentrate from such a product, it would be of great interest to have it more fully explained, rather than hinted at, and I feel sure that there would be a good market for this process.

S. A. IONIDES.

Denver, Colo.

#### True Chemical Energies of Combination

To the Editor of *Metallurgical & Chemical Engineering*:

SIR:—In your August issue Dr. Carl Hering writes of his investigation of whether it is a mere coincidence or likely to be a possible law that the true chemical energy of each bond between like elements is the same.

It occurred to me that the figures could be made to support this more closely if account was taken of the different kinds of bonds between like elements. In Dr. Hering's table (page 527) the first compound is  $\text{CH}_4$ —here all the bonds are alike, a single bond between carbon and hydrogen—therefore the energy between carbon and hydrogen equals the chemical energy of the compound ( $+61.0$ ) divided by 4 = 15.25. But the next compound  $\text{C}_2\text{H}_6$  has two kinds of bonds. It may be written  $\text{H}-\text{C}\equiv\text{C}-\text{H}$ . The value of the two single bonds equals  $+30.5$ , subtracting this from the chem-

ical energy of the compound ( $+32.8$ ) leaves  $+2.3$  as the value of the triple bond between two carbon atoms. The third compound is written  $\text{H}_2=\text{C}=\text{C}=\text{H}_2$ . By the same method the value of the double bond is found to be  $+8.6$  and of the single bond between two carbon atoms  $+16.0$ .

Energy between hydrogen and carbon atom = 15.25 kilogram calories.

Energy between 2 carbon atoms—single bond = 16.00 kilogram calories.

Energy between 2 carbon atoms—double bond = 8.60 kilogram calories.

Energy between 2 carbon atoms—triple bond = 2.30 kilogram calories.

With these four values the chemical energies are calculated by writing out the structural formula, giving each kind of bond its value and adding together. The results are tabulated below and are arranged with each series of compounds grouped together.

Compound	Chemical Energy	Calculated Energy	Difference
$\text{C}_2\text{H}_6$	$+156.8$	$+154.0$	—2.8
$\text{C}_2\text{H}_4$	$+203.5$	$+200.5$	—3.0
$\text{C}_2\text{H}_2$	$+116.9$	$+116.1$	—0.8
$\text{C}_3\text{H}_8$	$+171.0$	$+162.6$	—8.4
$\text{C}_3\text{H}_6$	$+217.8$	$+209.1$	—8.7
Benzene	$+241.3$	$+165.3$	—76.0
$\text{C}_6\text{H}_6$	$+289.3$	$+211.8$	—77.5
$\text{C}_6\text{H}_{10}$	$+330.0$	$+258.3$	—71.7

This table contains those compounds of which there are more than one of a series in Dr. Hering's table. Except for the compound  $\text{C}_2\text{H}_4$  there is a constant difference between the two values for each series of compounds. Does this mean that the energy of condensation is a constant for each series of compounds?

OSCAR BROPHY.

Philadelphia, Pa.

#### Cyanide Practice in the Porcupine District.—A Correction

To the Editor of *Metallurgical & Chemical Engineering*:

SIR:—In the table giving a comparison of methods adopted in the principal cyanide mills at Porcupine, page 636 in your October issue, I note an error in the column devoted to classifiers. The Dorr classifier is used at the Dome mill, and the Colbath at the McIntyre, instead of vice versa as published.

H. C. PARMELEE.

Denver, Colo.

To the Editor of *Metallurgical & Chemical Engineering*:

SIR:—In your last issue we note an article in regard to the operation of the Hardinge mills at the McIntyre plant in the Porcupine district. While the remarks ordinarily would be flattering they do the Hardinge mill a great injustice in stating that the material fed to the mill is  $\frac{1}{4}$  in., while in reality it would not all pass a  $1\frac{1}{2}$ -in. screen. If we assume it to be 1 in., which is not in itself as coarse as is being fed to the mill, still this 1 in. would be sixty-four times the volume of  $\frac{1}{4}$  in.—in other words, the Hardinge mill has received credit for only doing 2 per cent of the actual work it is performing.

This also applies to the Vipond plant, where a similar size material is being fed; in other words, the Hardinge ball mill is taking a stamp-mill feed.

H. W. HARDINGE.

Hardinge Conical Mill Co., New York City.

## The Non-Ferrous Metal Market

A general decrease in prices has marked the metal markets during the past thirty days. Regular copper quotations have not been resumed, and the prices at which sales are made are erratic and much below normal.

**Copper.**—Domestic demand has not improved much, and exportations are small. Sales have been made at about 11.5 cents, and there seems to be no immediate hopeful outlook for improvement.

**Tin.**—The demand for this metal has fallen off, and prices have consequently declined. The latest quotation is about 29¾ cents, New York.

**Lead.**—New York price has been reduced to 3.5 cents per pound, with little effect in stimulating business. St. Louis quotes 3.35 cents.

**Spelter.**—Both domestic and foreign demand has fallen off and prices are lower. The decline has been steady to about 4.65 cents, New York, and 4.50 cents, St. Louis.

**Other Metals.**—Quicksilver continues strong, with New York prices ranging about \$55 per flask of 75 lb. Business in antimony has been fair, with prices from 11 cents to 13 cents for various brands. Quotations for aluminium are 18@19 cents, New York, with little actual trading.

## The Iron and Steel Market

The iron and steel market has dropped to the lowest depths of stagnation seen for many years, perhaps, indeed, since the steel trade replaced the iron trade about a quarter century ago. The stagnation is due more to a mental than a physical state. Demand is light, not because buyers are overstocked, because prices are too high or because physical conditions do not call for the consumption of steel.

The depression is due in part to financial conditions and in part to extreme timidity on the part of buyers, bordering upon panic. It is not difficult to trace the development of thought through which the present condition was brought about. Immediately upon the inception of the European war the steel trade was filled with talk of an immediate expansion in demand, both domestic and export, and with fears that there would not be ferromanganese and magnesite sufficient to permit the steel being made that would be called for. A distinct though slight buying movement about the middle of August furnished concrete evidence that these views were more or less accepted in practice. Later it became certain that there would be no scarcity of any raw material and that the export demand would, for a time at least, prove very light. Money became tight immediately after the war started, but evidently it was weeks before business men realized how seriously the condition would restrict industry. Thus, on account of mistakes in judgment made in August the full measure of the depression has developed only of late, when with a quicker apprehension of the true state of affairs it is not impossible that by this time we should have been able to set ourselves on the road to recovery.

Steel buying has been constantly diminishing and has now reached a very low ebb, the total bookings, in specifications against contracts and in new purchases, chiefly the former, probably not comprising more than 30 or 35 per cent of the existing capacity. Declines in production have followed declines in buying, until at the close of October the average rate of steel mill operation is only about 40 per cent of capacity, against an average between 65 and 70 per cent of capacity during July and August.

Never before, as already indicated, has the steel market reached such a stage of stagnation. In all previous instances there has been a rebound when the rate of production dropped to about 50 per cent, but precedents are regarded as no criterion as to what may occur under these war conditions. So many mistakes having been made already, however, that the conservative observer need not take the popular judgment as final. Perhaps, after all, recovery will set in sooner than is generally expected.

The export demand for steel mill products is running at a rate well under the rate obtaining in the first half of the year, even though that rate, some 140,000 tons a month, was far below the record rate, about 245,000 tons as the monthly average of 1912. There is no prospect of any early and important improvement. The buying capacity in our regular export markets has been greatly reduced, and particularly in South America. The new export demand, for England, which early in the war gave considerable promise, has proved to be light, as activity in the British steel trade is so light that the flow of unfinished steel from Germany and Belgium, stopped by the war, does not necessitate the placing of any large orders in the United States. There has been, however, a fairly heavy demand for barb wire and nails from England, and to a lesser extent from Russia.

At midsummer stocks of finished steel in the United States were thought to have reached the lowest possible level, but they are now much smaller. Nothing approaching a close estimate can be made as to the actual rate of ultimate consumption, since the war has practically stopped the inception of new enterprises, while an indeterminate part of the consumption in recent weeks has been in projects already in course.

In one direction there has lately appeared considerable promise of improvement. While the steel trade has not directly felt any stimulus in export demand for its products, a considerable export demand has undoubtedly appeared in several other directions, including some industries that consume steel. Some large orders have been placed, for instance, for motor trucks and for lathers and other machine tools for export.

Steel buying has been so extremely light that prices are not seriously tested, but there has been a more or less declining tendency nevertheless, and where the end will be cannot be guessed. If the cost of production has been the determining factor in previous declines, and is to determine at this juncture, then the decline will not be to as low a level as in the past, for the mills will have a lower rate of production and consequently higher costs.

### Pig Iron

The rate of merchant pig-iron production has dropped to the lowest level in many years, and yet some iron is being piled, so that the trend is still towards a decrease in output. Buying is almost absent, but enough has occurred to develop slight declines at several points, and there is likely to be further yielding. Southern pig iron, while remaining at \$10, Birmingham, is lower at many delivered points on account of the reduction in freights. The rate to Cincinnati has been reduced from \$3.25 to \$2.90; to Chicago from \$4.85 to \$4.50 and to Pittsburgh from \$4.90 to \$4.55, though practically no Southern pig iron has gone to the Pittsburgh district for years. Prices are now approximately as follows: No. 2 foundry, f.o.b. Birmingham, \$10; delivered Philadelphia, \$14.20; f.o.b. furnace, Buffalo, \$12.25; f.o.b. furnace, Chicago, \$13; at valley furnaces (90 cents higher delivered Pittsburgh); Bessemer, \$14; basic, \$12.75; No. 2

foundry and malleable, \$12.75 to \$13; gray forge, \$12.50 to \$12.75. Ferromanganese has continued to weaken. The English price, on contract, is \$68, Baltimore, but re-sale material is offered for prompt shipment at \$65 or less, and there is practically no buying.

### Steel

A few sales, and a greater number of offerings, have developed considerably lower prices for billets and sheet bars. Consumers have old tonnages still due them and being confronted with very light operations for the near future are buying practically nothing. Billets are quotable at \$19.50 and sheet bars at \$20, at maker's mill, Youngstown, prices at maker's mill, Pittsburgh, being 50 cents higher. Rods are \$26, Pittsburgh, but are practically nominal at that figure.

### Finished Steel

Current prices as far as developed are practically as follows, f.o.b. Pittsburgh, unless otherwise stated:

Rails, standard sections, 1.25c.; for Bessemer, 1.34c. for open hearth, at maker's mill, except Colorado.

Plates, tank quality, 1.10c. to 1.15c.

Shapes, 1.15c.

Steel bars and bands, 1.15c.; hoops, 1.25c., base.

Iron bars, 1.15c., Pittsburgh; 1.00c. to 1.05c., Chicago, 1.17½c., Philadelphia.

Sheets, blue annealed, 10 gage, 1.40c.; black, 28 gage, 1.90c.; galvanized, 28 gage, 2.90c.; painted corrugated, 2.10c.; galvanized corrugated, 2.95c.

Steel pipe, ¾ in. to 3 in., 80½ per cent off list.

Steel boiler tubes, 3½ to 4½ in., 72 per cent off list.

Standard railroad spikes, 1.40c., Pittsburgh; 1.50c., Chicago.

Structural rivets, 1.45c.; boiler rivets, 1.55c.

Cold-rolled shafting, 67 per cent off list.

Chain, ¾-in. proof coil, 3.00c.

## The Western Metallurgical Field

### Heating Mill Buildings

As a general rule the cyanide and concentrating mills of the western United States require heating during the winter season. In some cases it is even customary to heat solutions throughout the year. For both of these purposes steam must be generated, either in conjunction with the power plant, or for the sole purpose of heating when electric power is purchased from a central station. In either event it is likely that live steam is used in most cases, and that heating with exhaust steam is not practiced to a wide extent.

There are neglected possibilities for economy in the use of exhaust steam for heating purposes. If a mill has a steam power plant, and live steam at reduced pressure is used for heating, there is a distinct loss in the waste of exhaust steam from the engines. If, on the other hand, the mill is supplied with electric power from a central station and a steam plant is installed for heating purposes only, the cost of that heating is almost as great as though a corresponding amount of power were first generated and the exhaust steam used for heating.

The relative fuel requirements for heating and for power production are not always fully appreciated. Writing on the subject of Preventable Losses in Factory Power Plants, Mr. David M. Myers gives some illuminating facts in the August number of the *Engineering Magazine*. Among other things he shows that about 90 per cent as much fuel is required to make live steam for heating requirements alone as for the production of power. In one case he demonstrated this by shutting down every engine in the plant and weighed

the fuel to the boilers which carried a heating load only, with the result that there was no perceptible difference in fuel consumption. In a case where steam at 125 lb. was lowered to 20 lb. by a reducing valve for the heating system, a 150-hp non-condensing Corliss engine was substituted for the reducing valve, expanding the steam down to atmospheric pressure before it was used for heating. The power thus produced, or about 90 per cent of it, became a pure by-product of the steam heating. It is essential, of course, that an exhaust-steam heating plant be properly designed, for otherwise the beneficial effects cannot be obtained and failure is likely to result.

Another point made by Mr. Myers is contained in the following quotation: "A common error among plant owners is to ascribe undue economy to the heat that may be carried in water resulting from the condensation of steam. They conversely greatly underestimate the heat carried in exhaust steam. As a matter of fact the heat in a pound of water at 212 degrees is only 180 British thermal units reckoned above the freezing point; whereas in a pound of steam at the same temperature the heat units number 1150. Hence if this steam is condensed in a radiator it gives out 970 heat units, and the drip will contain 180 heat units. Nevertheless I have found the management very anxious about correcting the loss due to a few escaping drips, while at the same time large quantities of uncondensed exhaust steam were blowing away almost unnoticed. Pound for pound, the waste which attracted the manager's attention was equal to less than one-fifth of the heat being carried away in the disregarded exhaust steam. This is a good thing to remember, and it will stand twice telling: *Utilization of the exhaust steam saves five times as much coal as the return of an equal weight of hot drips to the boiler.*"

The whole subject of heating with exhaust steam is worthy the attention of metallurgists because it is quite possible that important economies can be effected in connection with the power plant.

### Anyox Smelter of the Granby Company, British Columbia

The new smelter erected by the Granby Consolidated Mining, Smelting & Power Co., Ltd., at Anyox, B. C., was designed to treat the ores from the Hidden Creek mines near Granby Bay, on Observatory inlet, about 110 miles northeast of Prince Rupert.

Each of the three blast furnaces measures 50 in. by 360 in. at the tuyeres. The sole plate is four inches thick and is formed of iron cast about coiled pipe through which cooling water is circulated. There are two rows of jackets; in the lower row on each side of the furnace there are six, each 54 in. wide, and one tap-hole jacket 36 in. wide. All are 10 ft. 6 in. in height. Those in the upper row are 60 in. wide and 6 ft. 8 in. in height. The tuyere openings contain thimbles that are fused to the fire sheet, extending through the air sheet of the jacket and beaded in place. The upper tier of jackets is supported from the mantle frame in such a way that the lower jackets can be removed without disturbing the upper tier.

The mantle frames of the three furnaces are connected, forming one continuous mantle. The sole plates extend beyond the end jackets, and it will be possible to extend the furnaces at any time to occupy the space of 15 ft. which intervenes between the middle and end furnaces, so that a single furnace of 120 ft. in length could be constructed without difficulty.

There are three basic-lined copper converters of the Great Falls type, each 12 ft. in diameter and 17 ft. 7 in. high. Thirteen tuyeres 2 in. in diameter are placed

with their axes at right angles to the axis of the shell. The tuyere pipes extend into the converter and are connected with the tuyere casting by a special coupling which permits removal of the casting without interfering with the pipes. Each converter is operated by a 50-hp motor through worm gears.

Additional information on this and other smelting plants in British Columbia is contained in a publication recently issued by the Department of Mines of Canada. The report, which is edited by Dr. Alfred W. G. Wilson, presents a historical review of copper smelting in Canada and includes descriptions of the plants now in operation: Canadian Copper Co., Mond Nickel Co., Consolidated Mining & Smelting Co., Granby Consolidated M. S. & P. Co., British Columbia Copper Co., and Tyee Copper Co.

#### New Cyanide Mill for Rochester Mines Co., Nevada

The design of the new 100-ton cyanide mill for the Rochester Mines Co. at Rochester, Nevada, construction of which is now under way, presents some interesting features, particularly with reference to continuous counter-current decantation. The equipment of the sampling department comprises the following machines in sequence: Blake crusher, elevator, No. 3 Vezin sampler, Dodge crusher, No. 2 Vezin sampler, rolls, and No. 1 Vezin sampler. Metallurgical treatment will begin by crushing in solution with ten 1550-lb. stamps. The stamp discharge will be classified into sand and slime in a Dorr classifier specially designed to give

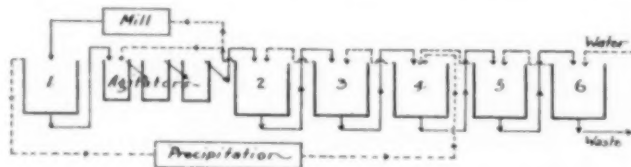


FIG. 1—SCHEME FOR CONTINUOUS DECANTATION AT ROCHESTER MILL

extra settling area, being deeper and longer than the standard machines. The grinding will be completed in two 5 ft. by 16 ft. tube mills connected by clutches with a single 100-hp motor equipped with silent-chain drive. The classifier overflow will contain probably 95 per cent of minus 200-mesh pulp.

The equipment for recovery of pregnant cyanide solution will consist of one Dorr thickener 28 ft. by 12 ft., followed successively by three Dorr agitators 28 ft. by 16 ft., and five thickeners 28 ft. by 10 ft. The agitators will be operated in series, with a drop of four inches between successive machines. The last five thickeners have, successively, 2 ft. greater elevation to provide for return of decanted solution by gravity. Diaphragm pumps will be used to elevate the thickened pulp through the series. The pumps will be driven from adjustable eccentrics on an overhead shaft, a 7-ft. rod connecting the diaphragm with the drive. This scheme is expected to materially lessen the wear on the diaphragms due to lateral motion.

The general scheme for continuous decantation which was finally adopted after considering the conditions peculiar to this proposition, is diagrammatically represented in Fig. 1. It will be observed that there are six thickeners, five following the agitators instead of four as is customary in other installations. It was first proposed to use only five altogether, with double precipitation, precipitating not only the overflow from No. 1, but also that from No. 4. Under this scheme, the theoretical calculations indicated a loss of dissolved gold amounting to four cents per ton of ore treated, and a mechanical loss of cyanide equal to 0.61 lb. per ton of ore. The calculations for the present scheme, however,

using six thickeners and single precipitation, indicated dissolved loss of about one and one-half cents per ton of ore, and a mechanical loss of cyanide equal to 0.62 lb. per ton of ore.

Comparison of the figures will show that the extra decantation obtained in the sixth thickener, reduced the dissolved loss and still gave about the same mechanical loss of cyanide. A further reason for the adoption of the extra thickener was the possibility of occasionally treating high-grade ore—up to \$50 per ton—in which case the extra decantation would be a protection against loss of dissolved metal. It is interesting to note that a 15-hp motor provides power for all operations below the tube mills.

#### Chemistry at the American Gas Institute

The meeting of the American Gas Institute, held in New York City from October 21 to 23 in the United Engineering Building, brought out some interesting chemical papers, mostly presented before the new Chemical Section.

A paper of considerable chemical interest, by Captain FRED H. WAGNER of the Bartlett Hayward Company, of Baltimore, Md., on "coal gas residuals (Feld process)" was presented on October 21 before the Manufacturing Section. It is published in full elsewhere in this issue.

The chief chemical feature of the convention was, however, the inauguration of the newly formed Chemical Section. It was very successful in both its sessions in the morning and afternoon of October 22. While the members were somewhat tardy in coming in, the meeting room filled up very well in time, the attendance being somewhat like fifty. Moreover, there were good spirited discussions and the interest did not flag to the end.

#### Gas Analysis

The proceedings of the morning started with a report by W. H. FULWEILER, Philadelphia, Pa., for the Gas Chemists' Handbook Committee. The voluminous first report of 118 printed pages gives first an alphabetical index of what should be included in the Handbook, and secondly a description of methods of analysis of ammoniacal liquor, coal and coke, illuminating gas and furnace gas, impurities, gas oil, oxide, and tar. Mr. Fulweiler emphasized that standard methods of sampling were at least as important in practice as standard methods of analysis.

A long discussion followed in which Dr. Morehead and Dr. Elliott emphasized that the ultimate object of the work of the Committee should be a set of standard rules for sampling and analysis which would have to be adopted by the Gas Institute (like the Standardization Rules of the American Institute of Electrical Engineers). These rules would represent the final authoritative say in cases of dispute between seller and buyer of coke, for instance.

A paper on "a method for the determination of hydrogen sulphide in gas" was then presented by A. B. WAY of Everett, Mass. There was a lively discussion on "pet analytical methods." The general consensus of opinion seemed to be that Mr. Way's method was both accurate and quick.

#### An Electrical Process for Detarring Gas

Of considerable interest and great promise for industrial application was the paper by W. W. STEERE, Detroit, Mich., on a process which he has recently worked out, having formerly been connected with the research work of Prof. A. F. White, of the University of Michigan, on the electrical separation of tar from coal gas by the Cottrell process. While Cottrell uses rectified high-tension direct current, Steere employs

alternating current directly. This means simplicity of construction since with the simple use of alternating current the transformer may be mounted on the ionizer, one terminal may be grounded and the other connected directly to the electrode terminal. With the terminals and connections completely enclosed so that no high-tension parts would be exposed, and with no moving parts requiring attention or inspection the element of danger would be absolutely eliminated.

The process was worked out at the Detroit plant of the Semet-Solvay Company. The gist of the process is this: It is practically impossible in mechanical extractors to free the gas from tar in the extremely fine state of subdivision which naturally results from rapid condensation. But there is no difficulty in removing relatively large drops. Now the electrical treatment simply converts the fine mist into large drops.

The gas is subjected to an electrostatic treatment in the "ionizer" operated by alternating current, and the result of this treatment is that the fine mist of minute tar globules is agglomerated into large drops. The gas with the large tar drops is then swept into some form of mechanical extractor where a complete removal is affected with very little power loss. The Doherty centrifugal tar extractor worked very well to accomplish this; the old type P and A machine also became a very efficient tar extractor when placed after the ionizer.

Cleaning producer gas for use in gas engines is one of the later developments of this process and it is noteworthy to state that the process is now in commercial use at the plant of the Ford Motor Company at Detroit on the producer gas driving their large gas engines. The process was started at the Ford plant the 21st of January, 1914, and up to now has not been out of service one minute while the plant was running.

The paper elicited an extended discussion and in reply to the various questions asked, Mr. Steere stated that there is no decrease in calorific power of the gas. No deteriorating effects have been observed on the iron mains in nine months' work. The process is electromechanical rather than electrochemical. At the Ford plant the power consumption is between 1 and 1½ kw. The problem of insulating has been solved completely.

We expect to publish this interesting paper in full in a future issue.

#### Calorimeter

A paper on "tests of a new recording calorimeter" was next presented by C. H. STONE, Middletown, N. Y., and W. H. HINMAN, New York City. The instrument, built by the American Meter Company, is a regular Hinman-Junkers calorimeter fitted with a pair of special recording thermometers. The paper was read by Mr. Stone and the discussion closed by Mr. Hinman. In the discussion various speakers emphasized the great commercial need of a reliable recording calorimeter. The instrument was shown in the exhibit of apparatus on the ground floor of the building.

#### Bureau of Mines

The afternoon session was devoted to these papers contributed by the Bureau of Mines.

Dr. G. A. BURRELL presented a paper, by himself and I. W. ROBERTSON, on "the separation of the illuminants in mixed coal gas and water gas."

In this paper experiments were described made by the Bureau of Mines and which resulted in separating the illuminants in the mixed artificial gas of Pittsburgh. This gas is made by mixing one part of carbureted water gas with three parts of coal gas. The separation was made fractionally distilling the gas in a vacuum at low temperatures and follows the method detailed by the Bureau in separating natural gases.

Dr. HORACE C. PORTER then presented a paper by

himself and GUY B. TAYLOR on "the mode of decomposition of coal by heat." The object of the research was to analyze the process of carbonization in its different steps and to study especially the early steps by making use of a high vacuum with low temperatures of decomposition.

#### Gas Manufacture from the Point of View of Physical Chemistry

The last Bureau of Mines paper was presented by Dr. W. F. RITTMAN, who spoke forcefully and very interestingly. The day is past when gas making is primarily a mechanical operation. Carbureted water gas constitutes approximately two-thirds of the gas made today, and it is no longer possible to buy a high-grade paraffin gas oil for 3 cents a gallon. In 1913, Greater New York alone used approximately 3,860,000 barrels of oil in the manufacture of carbureted water gas. During 1913 the same plants used approximately 1,600,000 tons of coal. On the basis of heat units involved, oil has become as important in American gas manufacture as coal. During the last decade, the increasing price of oil for gas manufacture has created what many gas men regard as a "dangerous" situation; and this is true despite the fact that never before in the history of the United States has so much oil been produced as to-day.

The reason for this is to be found in the fact that the oil refiner, by extended research, has perfected processes whereby the oil which the gas manufacturer used to buy at 3 cents a gallon is now converted into gasoline and other products which sell at several times that price.

In a recent court hearing in Chicago interesting testimony was given by Mr. Frank B. Lewis, Jr., manager of the Standard Oil Company refinery at Whiting, Ind., regarding the Burton process. The Whiting plant is running exclusively on Mid-Continent oil. They are able to take it all and convert it all into gasoline except what coke is left in the still, and a little wax or petroleum tailings. The process has been in use for about one year.

Oil refiners all over the country are also working on methods to convert every pound of gas oil into more valuable products. Facing facts, this means that if gas men are to continue the use of petroleum in carbureting water gas, they must resort to one of two alternatives: first, they must greatly increase the yield of gaseous hydrocarbons from a given amount of oil, or second, they must perfect methods of using the millions of barrels of fuel oil which today are considered unfit for carbureting water gas. One often hears the statement that these so-called fuel oils cannot be used in carbureting water gas. What right does any one have to make this statement?

Dr. Rittman thought there is no reason to be pessimistic. He expressed the conviction that as soon as the gas manufacturer faces facts as they are, and seriously attacks the problem, increased efficiency and economy will result with petroleum still of primary importance as a raw material. Never in the history of the world has so much oil been produced as is being produced today. It is estimated that Oklahoma alone will mine 80,000,000 barrels. California will contribute 100,000,000 barrels. Never in the history of the United States has so much oil been in storage as today. We are not facing an oil famine. We are facing a famine of knowledge concerning the chemical behavior of inferior petroleum which will facilitate their substitution for higher-grade petroleum.

Dr. Rittman emphasized the necessity of systematic physico-chemical research at considerable length.

The different papers are copyrighted by the American Gas Institute, subject to the authors' corrections.

## Coal Tar Colors in America\*

BY I. F. STONE

It gives me great pleasure to be able to appear before you this evening, to clear up if I can, the general skepticism which seems to exist in connection with the manufacture of coal tar dyes in the United States.

That there is such an industry in the United States is a fact and has been for over thirty years. That we cannot compare with Germany in magnitude is, of course, true, and that we will be able to increase our production in the near future to take over all of the colors now supplied by Germany is also manifestly impossible, but that it is possible to increase the American production very materially is a fact, depending on certain conditions of which I will speak later in my remarks.

That there has been more or less prejudice against dyes made in America is also true, in spite of the fact that these dyes are fully as good as any made in Europe, and it has been a struggle to prove that the latter statement is absolutely true. Even at this late day there are people who would always give the preference to European dyes at the same price and quality, if they had an opportunity to do so, and are abetted in their belief very naturally by the European representatives. Only a few days ago among other letters we have received asking about the manufacture of dyes in this country, was one from a very substantial trade journal which circulates largely among the textile mills. Among other things it says:

"No one believes that the American dyestuff manufacturer can compete with the German. The Germans are counted wizards in dyestuff chemistry, and I doubt if you could interest a great number of manufacturers in a domestic product at the same price as quoted on exactly the same thing from Germany."

After a couple of pages of such argument it finally suggests that we take up the matter of advertising with them to change the sentiment of the buyers, which is very naive to say the least. But the point is if a journal with the influence of this one should express such sentiments among its subscribers, how unfair it would be to the American manufacturers of dyes, and it is simply an instance of one of the small things against which they are struggling.

On the other hand, in the past few weeks we were encouraged by numerous letters from actual consumers of dyes, among them some of the largest textile mills in the country, complimenting us upon the way we have been handling our products during the present abnormal conditions, and advising us that they would in the future give their preference to American colors whenever we are able to offer them in competition with foreign colors; in other words, able to supply them with the quantity of colors consumed, which hitherto we have not been able to do by reason of not having a production sufficiently large to take care of all the trade. So life does have its compensations and the American dyestuff industry from now on, in any event, starts out on an equal footing with the German industry, as far as the goodwill of the consumer is concerned, and it is, therefore, only a question of being able to produce a large enough quantity at competitive prices to insure a large proportion of the business of the United States for the American manufacturers.

Barely two months ago a comparatively small percentage of the population of the United States knew

anything about aniline dyes or dyestuffs, those who did know something being mainly connected with industries which used these products in their line of business. Even those who did use them had only a vague idea, as a rule, what they were and their source, except in a general way that they were made from coal tar and that Europe was the principal source of supply. They were even regarded by a large percentage of the consumers as a mere detail of their business, and were put in among the sundries with such items as oil, soap, and I might almost say paper, string, and such miscellaneous supplies, notwithstanding that it required the highest order of scientific training to produce these colors and a long experience and knowledge of them in order to sell them successfully. The average dyestuff salesman was received only with tolerance and usually referred to some minor employee of the owner for his interview.

Suddenly something happened. A great war was declared, and the great source of supply was one of the principal nations involved. Some buyer, more intelligent than the ordinary one, discerned that the supply of dyestuffs would be more or less limited if not entirely cut off under these conditions, and immediately made attempts to secure a good supply for his future wants. The news soon spread among others until there was a general scramble for dyestuffs, and men who ordinarily gave this matter very little attention are now looking after it personally, and interviewing and corresponding with the heads of such firms as they thing can supply them with their wants. The newspapers took up the matter and published columns of more or less accurate information as to the situation. The general public was, therefore, given an idea of what was going on, and now know more of the source and supply of aniline products than they ever knew before.

The unfortunate conditions now prevailing have at least been of some good in a small way in educating our people here to the fact that they should be as independent as possible of other nations in connection with their supply of such products as are needed in this country, and there is now a general demand that the production of aniline dyes as one item should immediately be developed to such an extent that we would be independent of all other nations.

The serious question now, therefore, is whether or not such industry can be developed to such an extent, and this question can only be answered by some extended and more or less superficial explanation of conditions. It is not my intention to put before you a scientific or technical paper on the subject, as most of you are more or less familiar with the general conditions surrounding the manufacture of these products, or at least can easily read up in detail in any of the standard publications on the subject. I do wish to give you, however, a practical statement of the facts so that you will see why the industry has not developed in this country as it has in Europe, more particularly in Germany, as other nations are no further advanced than are the United States.

Aniline, as you know, is a product of coal tar, that is, coal tar is the primary raw material from which colors are produced, and it was obtained originally in the manufacture of coal gas, but of recent years a large and constantly increasing quantity has been obtained from the coke ovens used for making hard coke.

The first distillates are such products as benzol, toluol, xylol, phenol (carbolic acid), naphthalene, anthracene, etc., and these are produced largely in the United States as well as in Germany. Benzol,

\*A paper read before the New York section of the American Chemical Society on October 9, 1914. A report of the meeting will be found elsewhere in this issue. (See p. 684.)

for instance, which is probably the most important of the group, is not only used as a base for the manufacture of intermediate products for the manufacture of aniline dyes, but is also used largely as a solvent in place of benzine and gasoline, and, in fact, in Europe is used largely as a fuel for automobiles as a substitute for the same products. The prices at which it sells in this country are practically the same as in Europe, as are also, in fact, the prices of the other distillates first mentioned.

Up to now the supply has kept pace with the demand and there is no overproduction, but if the manufacture of dyes is to be considerably extended it will then be also necessary to extend the production of benzol, and this can be done in the course of time by getting the assistance of those coke ovens which do not at present recover their benzol, to put in appliances for doing so. Their interest in the matter, however, depends on their ability to make a profit on this recovery. There is, therefore, a chance that the price of benzol may increase to some extent for this reason.

Another of importance is naphthalene, which is made largely because there is a large demand for it, the consumption in the United States being upwards of nine or ten million pounds, not alone for its use in the manufacture of dyes but more for its use as a moth preventive, it having a large sale for this purpose all over the land. Of the quantity consumed here about one-third is produced in the United States, while the balance comes about equally from Germany and England.

It is evident, therefore, that the United States starts out on an even basis with Europe as far as the supply of the first raw materials is concerned, and that the natural resources of this country are available for an increase in the products which are manufactured from this source. So, in the beginning, for raw material we are as well placed here as they are in Germany; in other words, this is not a hot-house industry as some people have claimed, but is a part of the natural resources of the United States.

From these distillates are manufactured what we call intermediate products, such as nitro-benzol, aniline oil, aniline salts, toluidine, xyloidine, cumidine, benzidine, binitro-benzol, nitro-benzol, sulfo-acids, and a host of other products, a list of which can be had from any good textbook on chemistry if you are interested in looking them up further.

It is here that the first check in the economical manufacture of aniline dyes is encountered, for the reason that with one or two exceptions which I will mention later, none of these intermediate products are manufactured in the United States, because up to now there has not been a large enough demand for them to make their manufacture economically possible, while on the other hand, Europe—Germany particularly—has so developed the demand for these intermediate products that many plants have been established for their manufacture, most of them specializing on certain products, while some specialize on others, so that in the aggregate they are all produced on the most economical basis.

Up to within recent years few of the aniline dye manufacturers manufactured these products themselves, but depended largely on the aforementioned so-called specializing factories for their supplies, but this is now changing and some of the large color manufacturers are now making the principal intermediate products themselves although none of them make everything which they use. It is then very necessary, if the United States is to be independent of Germany, that these intermediate products be

manufactured on a large scale in this country, and it is here that we ask the Government to start in with a sufficient protective duty to allow the business to be developed. The present duty of 10 per cent, which was only put on in the last Tariff Bill, is really not sufficient for the purpose, while before that time the group being free of duty there was no incentive to begin their manufacture here.

One exception which is manufactured here is aniline oil, the manufacture of which was commenced about three years ago, and the quantity now produced is about one-quarter, and perhaps more, of the total consumption of the United States, taking oil and salts as one product. The quality is very satisfactory as compared with the German and English products, and has been used by our factory in the manufacture of aniline dyes since the beginning. In fact, if it were not being produced in this country at the present time the American dye manufacturers would not be able to continue to run, as they would be unable to obtain supplies from Europe. Consequently, as a result of this, manufacturers here are able to relieve the scarcity of aniline dyes, and have been of great benefit to American consumers by so doing, and will be a great factor in this relief as long as these unfortunate war conditions continue, so illustrating the great benefit to the people at large in having this class of products manufactured here, and so be entirely independent of Europe, under any conditions.

Unfortunately, however, the commercial side of the manufacture of aniline oil has not been so satisfactory for the reason that in the beginning they had no protection in the way of duty and were compelled to compete on an even basis with Europe, which could not be done successfully. They did, however, succeed in securing a duty of 10 per cent under the present tariff, which went into effect in October, 1913, just a year ago, but unfortunately this did not avail them anything in the beginning for the reason that the convention which controls the production of aniline oil in Europe immediately reduced their prices 10 per cent, to effect this duty so that we were no better off here than before. This is a sample of what is called unfair competition on the part of European firms in their attempt to prevent the increase of the aniline industry in this country, but could be readily checked if our Government would incorporate in their tariff what is known as the "dumping" clause, which is a clause forbidding the importation into and the selling in the United States of any products at a less price than they are sold in the country of production.

In spite of this check, however, the American manufacturers will continue the manufacture of oil, hoping that conditions will change in the near future so that they may be able to do so at a profit, and when this object is attained their plans are then to take up the manufacture of other intermediate products until everything necessary is finally manufactured here. As a matter of further interest, I might say that our own factory in Buffalo made aniline oil thirty years ago, but were obliged to give up its manufacture at that time owing to their inability to secure benzol. This situation is, however, now changed, as sufficient benzol should be obtained to continue the manufacture under advantageous conditions.

The other exception to my statement that these intermediate products are not manufactured here is nitro-benzol, known also as crude oil myrbane, which is in some demand from outside industries as well as the aniline industry, but not to so large an extent as aniline oil, and which is made here from time to time as conditions warrant; in other words, when it can be made at a profit in competition with Europe.

There is another demand springing up for these intermediate products, which may increase their consumption to such an extent that there will be a large demand entirely outside of the aniline industry, for instance, in the manufacture of smokeless powder and other explosives. The manufacturers of these are now using such products as diphenylamine, tri-nitro-toluole, nitro-benzol, pyridine, nitro-naphthalene, etc., and will finally create a demand which will necessitate their manufacture in this country as a matter of safety. For if the Government depended on explosives made from these materials it will in self-defence have to create some sort of subsidy or tariff protection, making it possible for their manufacture irrespective of European competition.

This is also true, by the way, of carbolic acid, which is a primary coal-tar product, and which is used in the manufacture of picric acid, an explosive product used by the Government. Carbolic acid is not being manufactured here at present to any extent and is now being practically unobtainable from Germany or England by reason of these countries having placed an embargo on this product.

From these so-called intermediate products we then come to the manufacture of the actual aniline dyes as sold in commerce, and their number is voluminous and complex. My good friend Dr. Hesse, for instance, recently stated in a published letter that there were some nine hundred different manufactured products, most of them as different each from the other as a pair of shoes is from a pair of socks. Of these nine hundred he observed that some seventy-six are now made in this country, but that this number is apparently not sufficient to meet the users' demand. In this statement I am quite ready to agree with him, except that we now make nearly one hundred types, which is more than he gives us credit for making. I will say, however, that of these nine hundred original types a great many are obsolete and probably we could get along quite well with a much less number, but as the one hundred made in America are all live types and those which can be manufactured regularly, you will see we are making really a much larger percentage of the total than is apparent at first glance.

In fact, I might almost venture the statement that with the hundred or so types already manufactured here, together with perhaps a few more which we would be prepared to take up on short notice, we would be able to furnish the American consumer perhaps 90 per cent of their color demand, speaking now of types or shades and not of quantity. The other 10 per cent which we could not furnish are such products as alizarines, indigo and patented specialties which would require large installations which would take a long time to complete.

It would perhaps be interesting in connection with these colors to give a hasty sketch of their beginning and development until the present time when they have resulted in the great chemical industry of Germany, the investment of millions of dollars and the employment of thousands of people.

The first color discovered was mauve, which is a sort of violet, by Perkin, in 1856. Then followed magenta and fuchsine in the same year, and a small establishment for the manufacture of same in England, which was not, however, very successful. Then came in 1862 the discovery of soluble or water blues, then the discovery of Hofmann's violet about 1863, Bismarck brown in 1863, then naphthol or martius yellow in 1864, nigrosines in 1867.

It was about this period that the Germans became actively interested in these products, and commenced their patient, intelligent and careful researches into

the subject, which later resulted in the most wonderful discoveries and the development of this industry in their country.

Then followed the discovery of orange, fast red, chrysoidine, malachite green, ponceau (scarlet), methylene blue, eosines, and metanil yellow about the years 1875, 1876, 1877 and 1878, and the manufacture then became one of recognized merit and importance.

After 1880 followed in rapid succession the discoveries of auramine in 1883, tartarazine in 1884, benzo purpurine in 1884, congo red in 1885, benzo azurine in 1885, naphthol black in 1885, diamine red in 1886, rhodamine in 1887, to mention only a few of the best known and most successful colors.

From 1880 to 1890 might be called the golden period of the business. Just prior to that time alizarine had been discovered, red in 1871, blue in 1877, patented, and successfully produced and sold at high prices with correspondingly large profits, and it was about that time that our German friends discovered the advantage of securing an exclusive market in the United States through their patents, which enable them to sell at high prices here although continuing the manufacture in Germany. The profits from such patented products as alizarine, benzo purpurine, diamine red and other direct dyeing cotton colors, auramine, rhodamine, tartrazine, and other such colors which were discovered and put on the market in that period, were enormous and put the German industry immediately on such a high pinnacle of success that it has continued until the present time.

In the nineties came the discovery of such important products as direct blacks for cotton and acid and chrome blacks for wool, the total consumption of these blacks being much larger than all the other colors combined.

It was also at this same period that began the first of the patents on synthetic indigo, of which there are many, and which was finally put on the market at such a tremendous expenditure that it has only been a commercial success in the past few years, finally being such a success that it has replaced the natural indigo practically altogether.

I might say in connection with the development of colors, that in the nineties came also the development of such pharmaceutical products as phenacetine, antipyrin, etc., which paid enormous profits to the manufacturers and which were also controlled by patents.

Such, then, is the wonderful development of the coal tar industry, there being invested at this time in Germany something like four hundred millions of dollars (probably more) and the employment of some fifty thousand people in factories, paying dividends to their stockholders, some of them 25 to 30 per cent, and that after charging off a third of their profits to sinking funds for the erection of new plants and for other such purposes. In fact, this has been done for so long a period that most of the present property and plants do not appear on their books at all as an asset, but have been built from the surplus profits. This statement is made on the basis of balance sheets for 1913 issued by one of the great factories, this factory having a capital of 55 million marks (\$13,750,000), but whose stock is selling for over six times par value, showing that the actual capital in the business was at least four times the shares issued, or some 200 million marks (\$50,000,000). On a capitalization of 55 million marks they showed a profit of 25 million, or nearly 50 per cent, one-third of which was written off for their real estate and plant account, leaving about 16 million marks from which they paid a dividend of 28 per cent.

Assuming that I am correct in my estimate of some

400 million dollars being invested in the industry in Germany, and assuming that a fair proportion of their production is shipped to the United States, it would mean that if the United States were to develop this industry to take care of all their consumption here they would need millions of dollars and would need to employ thousands of people. This will give you an idea of the magnitude of the business that it is now proposed that we establish here to its full extent.

It might be interesting at this point to give you the amount of aniline products imported into the United States from these European factories, the figures being for 1913: Aniline dyes, about \$7,000,000; Indigo, about \$1,000,000; alizarines, about \$1,500,000, a total of about \$9,500,000. These figures are, however, cost prices, and when the American duty of 30 per cent is added on aniline dyes, and further amounts are added for expenses and profits on their sale here it means that the American consumers are really paying something like \$12,000,000 for their supplies, not counting the colors produced in America, which may perhaps reach about \$2,000,000 more, the production in America, by the way, being some 15 to 20 per cent of the total consumption. These figures do not include the importation of pharmaceutical products which are made from coal tar, this being in itself a large business.

Our German friends are entitled to all the benefits which have accrued to them by reason of their shrewd, intelligent and careful attention to this industry, but with such a statement as the above, does it not seem as if they had had enough and it is now time for the United States to participate in this great industry when they are so well prepared to do so by having as good, if not better, natural sources than has Germany, and being consumers of so large a proportion of the German products? We must admit at once, however, that the United States cannot compete with the German manufacturers under normal conditions, first because they have a great advantage in capital, experience, and the general advantage of everything that goes with a successful and enormous business; and second, because the actual expenses of producing in Germany through labor conditions and so forth are much less than in this country, so that some way must be devised that the United States can be put on a competing basis. This can only be done in two ways:

First, by a sufficient protective tariff, which does not necessarily mean, by the way, that this will increase prices to consumers, although many people seem to be of this opinion. For instance, in an article in the *Scientific American* of September 26 they fall into this common error in stating that with an average importation of about \$6,000,000 worth of coal-tar dyes in the last thirty years we have a total importation of \$180,000,000 during that period, and assuming that duties had been 10 per cent higher than was actually the case this means that a total of \$18,000,000 would have been paid as an insurance premium against the possible event of the war such as that which is now distressing commerce. In other words, they mean that the American consumers would have had to pay this large amount of money more if there had been a 10 per cent higher tariff than they had been paying under the various tariffs which had been in effect during that time.

Even if the *Scientific American* were correct in their statement that \$18,000,000 would have been paid as an insurance premium in thirty years, this would really be cheap insurance compared to the enormous value of the goods manufactured in which the colors were used, assuming the colors with which to manufacture these goods could not be obtained in the neces-

sary quantities either from Europe or by an increase in the American manufacture. When I speak of goods in which aniline dyes are used I mean a whole range such as textiles, leather, paper, silk, paints and the hundred and one other manufactured products in which the use of aniline dyes is necessary.

In my opinion, however, based on experience, just the contrary to the *Scientific American* opinion is true, for the reason that a higher tariff would have stimulated production and competition and competition always controls the price, and this is shown clearly by actual facts. For instance, on indigo and alizarine colors there is no duty, and as a consequence they are not made here. Theoretically, therefore, they should be sold very cheap, but as a matter of fact by reason of no competition here they are controlled by conventions in Europe which make a uniform price and consumers are, therefore, unquestionably paying more than they would have to pay if such products were made here in competition. On the other hand, take, for instance, direct cotton black, which is an aniline dye which has a protective duty of 30 per cent, and which is made in this country in large quantities, and on which the Europeans have been obliged to reduce their selling price in this country to less than they sell for in Europe, so that American consumers are enjoying prices as low as 17 to 18 cents for a color which sells at from 22 cents and upwards in Europe under normal conditions.

Does any one believe that the low prices would have been made in this country were it not for the competition here, and does it not therefore prove that competition here regulates the price and that it is not so much a question of duty? What the American manufacturers want is not so much a high duty as it is that they want enough to equalize the difference in manufacturing conditions between this country and Europe and protection against the so-called unfair competition referred to in my remarks in connection with aniline oil; in other words, the inclusion of the so-called "dumping" clause. With a proper tariff on these lines the business could be successfully developed.

I might say further that if we could get our intermediate materials at the same prices which are paid by the Germans, and then secure for our colors the same prices obtained by the Germans for finished colors in other countries, plus the actual American duty, the problem would be solved, as this actual American duty if sufficient would then cover our extra cost of manufacturing, and put us in the exact position as are the Germans as far as our selling prices are concerned.

Secondly, as to the modification of our patent laws, so that they would require the manufacture in the United States of all such articles for which patents are issued. England has within the past few years made such changes in her patent laws, and as for Germany, she has always required the manufacture of patented products in her own country. Her present law reads in general that the owner of a patent must work the invention to an adequate extent in this country (Germany) or at all events do all that is necessary to secure such working, and if he does not, then if the public interest is such that the granting of permission to others to use the invention appears needful, it is granted by making some arrangement with the owner of the patent so that he received adequate compensation, but the manufacture of the product itself is insured for Germany.

About 1909 a similar clause was threatened in the patent laws of this country, and to head off such action Germany negotiated a treaty with the United States by which the German working clause was made inoperative on American inventions. In other words,

in return for the United States allowing Germany to continue to manufacture her products in Germany and export them to the United States, the United States was allowed a similar latitude in exporting her patented products into Germany. Whether or not the financial results of this treaty were beneficial to the United States is a question, but it certainly did not work out to the benefit of the United States as far as coal tar products are concerned.

In what I have already termed the golden period of the industry, viz., from 1880 onward, there was from 1880 to 1883 a duty of 35 per cent ad valorem and 50 cents per lb. specific, which gave ample protection to the industry, and as a consequence there were nine or ten factories in the United States, and the prospect of becoming independent of other nations for our supply of these aniline products was bright indeed, but the passage of the Tariff Act of July 1, 1883, which abolished the specific duty of 50 cents per lb., leaving only the ad valorem duty of 35 per cent and fixing a 20 per cent duty on the intermediate products, which left only a net protection of 15 per cent, immediately checked the industry here. No new factories were started, and within one year after the new tariff took effect five of those already established were forced to succumb and go out of business, leaving only four to continue the work. Those four would have gladly followed their example but had invested large sums of money in plants which would be an entire loss if abandoned. So they decided to continue to operate their factories, hoping for more favorable legislation in the future, but thus far they have always been bitterly disappointed. No tariff since that time has given them sufficient protection to develop the business to any large extent. Of course, a specific duty of 50 cents in those days was not abnormal, as the selling prices of the colors were so much higher than at present, and if a proper duty had been continued it would have had the same beneficial effect, but the abandonment of a sufficient duty has left open the admission of colors on a basis which really gives no protection at all.

In addition to the first or protective question as a stimulant to the creation of this industry in America, and coming to the second reason—the patent situation—if the Government had in the same golden period, viz., the eighties, required the manufacture in this country of all products for which they issued patents, then it would have at once created a large industry here. The European patentees would have been forced to build factories here to make these products. This means it would have resulted in branches of the European factories in this country, which would undoubtedly have developed into other products even though they might have originally only been erected for the manufacture of patented articles. While this would not have helped the then American factories it would at the same time have inevitably created a large industry here with beneficent results to the country at large.

As I have stated, there are now four factories in the United States manufacturing aniline dyes, our own factory having been established in 1879. While of slow development, at the same time it has been successful to the extent that it has kept in business and now manufactures practically all of the seventy-six different colors mentioned by Dr. Hesse, or, to be correct, the one hundred, to which I referred in the beginning of my remarks, these colors being all of the original colors, such as Bismarck brown, magenta, chrysoidine, fast red, water or soluble blues, eosines, nigrosines, a comprehensive line of direct dyeing cotton colors, and a comprehensive line of acid and chrome colors for wool and silk. This could easily be extended

to the manufacture of practically all of the necessary colors now demanded, and which are not covered by patents, so giving the consumer a large variety to choose from, and insuring practical independence of Europe under any conditions. This would be a large business in itself, except by comparison with the great German factories which stand alone in their magnitude.

All of the American factories will continue to manufacture colors to the best of their ability, but they cannot promise any extensive increase in their production without the support of the Government in the line of tariff protection, and incidentally, the change in the patent laws. The latter, however, is not now quite so important as to colors for the reason that many of the original patents have expired and we are free to manufacture a large line of colors provided it is made commercially possible for us to do so, we having already demonstrated our ability to do so as far as experience and willingness are concerned.

I might mention, as far as our own factory in Buffalo is concerned, which by the way, is widely known as the "Schoellkopf Aniline Works," we were the pioneers in the manufacture of such products as nitro-benzol, nitro-toluole, binitro-toluole, binitro-benzol, aniline oil, aniline salts, dimethyl-aniline, and quite a range of sulfo-acids, some of them of our own invention, which are necessary for the manufacture of both acid and direct colors.

We have also made such products as pure carbolic acid and pure naphthaline, but were obliged to give them up as well as the others because we could not compete with the European manufacturers, but we are now hoping that they can again be taken up either by us or by possible manufacturers of intermediate products, and the manufacture continued successfully in this country.

Under the present abnormal conditions our factory is again making some of these products in order to keep in operation as just at present it is not a question of price, but of ability to manufacture aniline dyes almost no matter at what cost, such is the demand. But, whenever conditions become more normal again, then we will necessarily have to give up the manufacture of these intermediate products for the same reasons that we have had to give them up before, viz., that we can purchase them in Europe at lower prices than they can be manufactured here.

I might mention further that our factories in Buffalo are still controlled and directed by Mr. J. F. Schoellkopf, who originally established them, being assisted a little later by his brother, Mr. C. P. Hugo Schoellkopf, so that they have had nearly thirty-five years of continuous experience in the manufacture of aniline products, and are fully competent to continue the manufacture in a large way should conditions develop so they can be increased.

This paper is not intended to appeal for sympathy or help from the Government or from American consumers. We happen to be so placed for the past few years that we could not develop our business as it might have been developed under different conditions. The American factories even as they are, are prosperous, and quite able to take care of themselves up to a certain point. But this paper is intended to show that the business cannot be extended to large proportions for the protection of American consumers, unless with Government help as to tariff and patent laws, as well as the assistance of the consumers themselves, which means giving the American manufacturers the preference wherever they can do so and assisting them to secure the necessary help from the Government.

Here then is a superficial history of the progress of

the aniline industry from its inception to the present time, not only in this country but in Europe, and the situation as related to the present and future manufacture of these products in the United States fully explained. Will the United States Government continue its indifferent policy of practically allowing this important industry to drift along as heretofore, or will it now wake up and seize the opportunity to make itself independent of all other nations in its supply of coal-tar products not only for aniline dyes for commercial purposes, but also for pharmaceutical products which relieve illness and pertain to the health of its inhabitants, and for products for the manufacture of explosives which would be absolutely vital in case of war. The future alone can answer these questions.\*

### The Situation in the Chemical and Dyestuff Industry

The first regular meeting of the New York section of the American Chemical Society was held on the evening of October 9, the general subject of the evening being a conference on chemicals and dyestuffs.

Prof. Allen Rogers, the chairman of the section, referred in his introductory remarks to the European war and the changes which have taken place in the dyestuff industry. He discussed concisely the most salient points to be considered—some 14 points in all.

Dr. J. Merritt Matthews followed with a paper on dyestuffs in the textile industries. He gave a review of the use of dyestuffs and various dyestuff materials—dyewoods, cochinel, and asked and discussed at length the question: Why do we dye our clothes? He then took up the relative merits of aniline dyes versus vegetable and animal dyes. Aniline dyes are uniform, exactly reproducible, and free from foreign materials. Dyewood dyes are not so; 78 different dyes are used in the United States. Dr. Matthews discussed wool dyeing, cotton dyeing, silk dyeing, mordants, and outlined the remarkable career of alizarine dyes.

Mr. Arthur Brill, editor of the *Daily Trade Record*, Millman's Section, followed with a paper on the campaign for the American dyestuff industry. The *Trade Record* tried to help the American dye manufacturers and textile mills, but met with much opposition. There was a remarkable fear on the part of many of the manufacturers to tell the public the actual state of affairs. They preferred to advertise: "Our textile goods will not lack in quality on account of poor dyes." We have large quantities of the best imported dyes." Accordingly this bluff puzzled dye manufacturers. It is high time that people ought to get together and frankly admit actual facts. Textile mills complained to the *Trade Record* that any frank acknowledgement of the state of affairs would reduce and has reduced sales.

Mr. I. F. Stone, president of the National Aniline and Chemical Company, followed with a paper on coal tar colors in America. On account of Mr. Stone's position in the industry and the authoritative character of his paper, we print his paper in full on page 679.

The last paper of the evening was presented by Mr. Alfred L. Lustig (chairman of the Dyestuff Committee, National Association of Finishers of Textile Cotton Fabrics): Needs of the textile industry.

\*Addendum.—After reading this paper, in reply to a question as to whether or not any original work had been done by the American dye manufacturers, that is, whether they had discovered any new products, Mr. Stone stated that sixteen patents had been taken out by the Schoellkopf Works between 1884 and 1903, comprising colors and intermediate products. One of these products, known as Schoellkopf acid, had been taken up by one of the largest German manufacturers and used extensively by them. Another product, direct black, had been taken up by another large German factory and also made extensively by them. Both products were used, of course, through arrangements with the Schoellkopf Works. So the question could be answered in the affirmative.

He spoke briefly on various points, especially tariff regulation, and emphasized that it was very often plain prejudice if the quality of dyes made in the United States was not considered equal to German dyes.

The attendance was very large, every seat in Rumford Hall being taken. A lively discussion was probably expected by many, but did not materialize. The discussion was short.

To sum up concisely the gist of the discussion of the evening:—The United States makes a limited quantity of dyes and small numbers of shades. There is a general uncertainty as to the duration of the war, as to new tariff legislation, etc. This holds back new undertakings. Americans refrain from enlarging their plants and introducing new processes, until a certain amount of assurance can be given that the enlarged industry will be protected in some way or other. There is no doubt that the aniline dyes are much better than dye-wood products.

### Chemistry in Lighting

The first meeting of the season of the New York section of the American Electrochemical Society, of which Dr. Colin G. Fink, of the General Electric Lamp Works, Harrison, N. J., is the chairman, will be held at the Chemists' Club, 50 East Forty-first Street, New York City, November 10, 1914. The meeting will be held by the New York section of the American Electrochemical Society with the co-operation of the American Gas Institute and the New York section of the Illuminating Engineering Society. The general subject of the evening will be the effect of chemical research on lighting.

A most interesting program has been prepared, as follows:

Dr. C. G. Fink:—Introductory remarks.

Professor M. C. Whitaker (of Columbia University, New York):—Improvements in the incandescent mantle.

Dr. William C. Moore (National Carbon Co., Cleveland):—Chemistry in the development and operation of flaming-arc lamps.

Dr. R. E. Meyers (Westinghouse Lamp Company, Bloomfield, N. J.):—The new tungsten lamps.

Mr. R. D. Bailey (Cooper-Hewitt Electric Company, Hoboken, N. J.):—The quartz-tube mercury-vapor lamp and its applications in chemistry.

Mr. D. McFarlan Moore (General Electric Company, Harrison, N. J.):—The new Moore tube lamps and the neon tube lamps.

Dr. Herbert E. Ives (United Gas Improvement Company, Philadelphia, Pa.):—The light of the future.

Arizona Copper Co. has reduced its production of copper in common with most other western producers. The output for August was 1869 tons of copper, but the September production will be lower.

Link-Belt Locomotive Cranes is the title of bulletin 158, just issued by the Link-Belt Company, of Chicago, Philadelphia and Indianapolis. The numerous excellent illustrations show the very large extent to which locomotive cranes are now used in the art of handling materials in the most varied industries. In the one machine is combined a portable hoisting engine, swinging derrick, grab bucket unloader and switch engine. The photographs from practice in various prominent fuel and iron and steel plants are particularly interesting. The chemical industries are represented by illustrations of locomotive crane practice of the Solvay Process Company, the Michigan Alkali Company and various sugar plants.

## The Gas from Blast Furnaces, Its Cleaning and Utilization

BY J. E. JOHNSON, JR.

The realization of the great heating value of the top gases of the blast furnace was very slow in taking useful shape. For centuries, furnaces ran with their tops wide open, discharging the gas into the air, with which it united in a great column of flame, visible for miles by night, even in the smaller furnaces of that early day.

Even after the invention of the steam engine, the possibilities of blowing furnaces by steam power were not practically realized for several decades and furnaces continued to be located primarily with reference to a suitable water power for blowing. In the same way after the invention of the hot-blast in the third decade of the nineteenth century the stoves were not at first heated by gas from the furnace, but were independently fired with coal.

Later a small chamber filled with iron pipes was built over the top of the furnace and the flame from the open top passed up through this, heating the blast which passed through the pipes. Still later flues were built into the brick work near the top, but just below the stock line and connected with a powerful chimney whose base was approximately level with the top of the furnace, this chimney drew some of the gas from the furnace, naturally much mixed with air drawn in from above, and the mixture burnt on its passage from the furnace top through the boilers and stoves to the chimney.

The final step was taken by closing the top of the furnace with a huge conical valve called the "bell" and forcing the gas by the pressure from below out through the flues into a pipe leading down to the ground level, where the stoves, boilers and stacks were located. This pipe early received and still retains the name of the "down-comer."

These top gases in Lake ore practice contain about 50 per cent of the total thermal value of the fuel charged. In districts where leaner ores are used and more fuel is consequently required per ton of iron the gas is correspondingly richer and contains a proportionately larger percentage of the thermal value of the fuel. In Lake ore practice an average analysis is about as follows: carbon monoxide 25½ per cent, hydrogen 3 per cent, carbon dioxide 12½ per cent, nitrogen 59 per cent. The thermal value comes entirely from the two former components.

The hydrogen comes partly from the moisture in the blast which is dissociated in the hearth, and partly from the moisture of the charge which is decomposed in the upper levels of the furnace. This gas under standard conditions of 32 deg. F. and 30 inches of mercury contains from 94 to 102 B.t.u. per cubic foot and has a specific heat of about 0.02 per cubic foot so that it contains about 2 B.t.u. of sensible heat for each 100 deg. F. above that temperature.

This gas is then somewhat more than half as high in heating value per cubic foot as ordinary producer gas. This with the enormous volume produced (some 140,000 cu. ft. per ton of iron in good practice and more where the practice is poorer) give it enormous commercial value, so great in fact as to equal a considerable percentage of that of the pig-iron itself.

This gas having been in intimate contact with the charge in its course up through the furnace, and having carried off all the moisture of the charge not dissociated, necessarily contains much moisture and picks up much fine dust from all the different components of the charge. It also carries a fume consisting of solids volatilized in the hearth of the furnace which

sublime into the solid state, but in the form of an impalpable powder, as the gas cools in its progress toward the furnace top.

It is this fume that gives the gas its characteristic appearance, so that an experienced furnaceman can tell more quickly by looking at the gas discharging from the boiler and stove stacks than by any other way if his furnace is working "hot" or "cold," since a relatively few degrees drop in hearth temperature make a great difference in the amount and appearance of the fume thrown off.

The composition of this fume will be treated more at length in a subsequent article; for the present it is only necessary to say that it consists mainly of silica, alumina, lime, potash from the ash of the coke, and iron, and in case the charge contains much manganese, this element is present in the fume to a great extent, changing the white color of the fume of a good working furnace on ordinary iron to a light yellow when running on "spiegel" and to a dark yellow or brown when running on ferromanganese.

In the early days of slow driving the velocity of the gas current through the furnace was small and the quantity of fine ore in the charge was almost negligible in comparison with the quantity of fine ore used to-day, which runs from 50 to 100 per cent Mesabi in the majority of American practice.

Under those conditions a single, comparatively small outlet at one side of the furnace top was sufficient and the quantity of dust carried by the gas was extremely small, therefore a single pipe of moderate size running straight or almost straight down and branching directly off to the stoves and boilers was all that was necessary to handle the gas. This constituted but a small, almost an insignificant fraction of the plant as a whole. Conditions at the present are vastly different from this in three respects:

First, the velocity of the gas through the furnace is several times greater than it was in those early days and the carrying power of the fluid current increases at an enormously rapid rate with an increase in velocity. I have seen the statement that this increase was as the seventh power, which would mean that doubling the velocity would increase the quantity of material carried 128 times. Whether this be true or not it is certain that the rate of increase in carrying power is extremely high.

Second, the ore used instead of being practically all hand-prepared lump consists very largely of fines, much of which is capable of passing through a 100-mesh sieve.

Third, we have come to realize the enormous cost of attempting to utilize gas in its dirty condition for stoves and boilers, even leaving out of consideration gas engines which require gas cleaner than the air we breathe for their successful operation.

These three causes have had an enormous effect on the gas-handling system of the furnace which has in recent years become one of the largest and most conspicuous features of the whole blast furnace plant.

### The Outlets from the Furnace Top

From the time of the closed top or soon thereafter, some furnacemen claimed that the gas should be taken off either from the center of the furnace or at several points symmetrically arranged around the furnace top. Others claimed that the gas, having gone through the stock column, had done its work and that the location of the outlet was a matter of no importance, and that one large outlet located on one side was cheaper and simpler than any other arrangement and just as good.

In connection with furnace tops, I shall show a design of top arranged to take the gas out at the center,

which worked successfully for many years and gave but little trouble. It was, however, impossible to make the top quite so simple in this way as with the outlet on one side, and so the great majority of furnaces built in the United States up to twenty years ago were constructed on the latter plan, although in discussing operation I shall show what is to my mind an indisputable proof that a single side outlet produces an unsymmetrical passage of the gas through the furnace and cannot lead to the best work.

As furnaces and their outputs grew they produced a vastly larger quantity of gas, so their designers provided more gas outlets, two and even up to five or six. Good practice now very generally uses four, though in my judgment three properly located are sufficient.

#### Downcomers

This introduction of multiple outlets introduced other difficulties into the design of the plant.

With a single outlet the down-comer could drop almost vertically to the ground close to the base of the furnace, but with this growth of output, necessitating multiple outlets, came the vast increase of dust which I have mentioned and the necessity for providing some means for its removal. As long as the gas traveled on a steep downward slope the dust would accompany it, but when the dust reached the horizontal passages leading to the stoves and boilers and from these to the stack it settled in them and obstructed them so rapidly as to constitute a serious obstacle to continuous and satisfactory operation.

Means therefore had to be provided for the removal of the dust at the foot of the down-comer and for this purpose chambers, at first only a little larger than the gas mains were introduced, but as conditions grew worse and worse these were increased in size and required therefore to be placed further from the furnace in order to give the necessary room for operation.

This threw the foot of the down-comer away from the furnace at its base, while the necessity of reaching more than one outlet threw its top back, from the closest point on the top of the furnace shell, to the center line of the shell when two outlets were used, and finally to the back or opposite side when four or more were used. These two factors flattened the slope of the down-comer from almost vertical to a slope well below 45 deg.

In some of the earlier installations these conditions were made still worse because it was considered necessary to have the down-comer enter the top of the dust-catcher in the center of the latter and this reduced the vertical height at the same time all the other factors above mentioned increased its horizontal reach. I think that the slope of the dust-catcher on some of the plants built about the time of the Duquesne revolution was not more than 30 deg. These were extremely unsatisfactory in operation because not only would dust lodge in them but also coke and other materials from the charge; they did not free themselves under any circumstances and no matter how large they might be built they filled up until the velocity of the gas through them was great enough to scour a passageway through the accumulation on the bottom slope, this of course involving high top pressure and consequent leakage on every joint not tightly sealed.

#### Explosion Doors

Down-comers are generally provided with explosion doors for two purposes: First, when furnaces are stopped it is almost impossible to prevent air being drawn into the gas main at some point or other. This air mixes with the gas and produces an explosive mixture. When operation is resumed this mixture is

ignited at the boiler or stove burners and an explosion follows which in some cases is violent enough to burst the main, dust-catcher and down-comer unless it is relieved by suitable safety-valves or explosion doors.

Second, the furnace itself is liable to slips or explosions in which a pressure of several pounds to the square inch, ordinarily only occurring at the lower levels of the furnace reaches the top and would do it great damage unless properly relieved.

This later theory has been combatted by Mr. Julian Kennedy who has claimed that explosions were more violent in proportion as they received freer vent; comparing the conditions which arise at such times to those occurring when the cork is removed from a bottle of charged water, if this be done suddenly a great proportion of the contents of the bottle is violently ejected, but if the cork is held back and the gas pressure allowed to pass off slowly none of the contents of the bottle are thrown out. In accordance with this theory the tendency in recent years has been to provide many less explosion-doors than were formerly thought to be necessary, and the results have very largely confirmed the theory, though many furnace-men are not willing to go as far as advocated by Mr. Kennedy and do away with explosion doors entirely.

One design, made about the time of the Duquesne revolution, was intended to be the best possible regardless of expense. Some five or six outlets were provided around the top of the furnace and these were all connected with an annular main, from one or two points on which the branches of the down-comer led off. Explosion doors were arranged on the outside of this annular main, which, of course, was a few feet below the operating platform of the furnace top and in order to provide access to it a supplementary platform was built a few feet below.

This system had almost all of the disadvantages which could be worked into one design. On the side opposite to the down-comer there was so little current of gas that the annular main became sufficiently choked up to make it virtually useless and one or two outlets on the side next to the down-comer carried off all the gas, practically as though the annular main did not exist. On account of the large size and distant location of the dust-catcher and the wide stretch of its branches to reach the opposite sides of the annular gas main the slope of the down-comer was exceedingly flat and it is probable that after it was in operation a short time more than half its area was choked up and not in active use. One of the worst features of the design was the location of the explosion doors which, it will be seen, came just under the main operating platform. Owing to the choked condition of the down-comer the top pressure was high and the explosion doors were generally leaking more or less; if the gas caught fire it burnt underneath the top platform so as to damage the steel work, and if it escaped unburnt the gas came up onto the top platform in sufficient quantity to make it dangerous to stay there any considerable length of time.

It may not be amiss to say a word here as to the general design of explosion doors. These are always made hinged, but are located in two different ways; first, so that the plane of the door is horizontal when closed; second, so that it is steeply inclined or vertical when closed. The latter design is radically wrong and should never be used because the moment of the door due to its weight is little or nothing when it hangs vertical, consequently a slight pressure is sufficient to force it from its seat, but as its moment rapidly increases a much greater pressure is required to force it to open wide as it should when it is needed at all.

The horizontal door works exactly the opposite way

exerting its maximum moment when it is closed so that it is very easy to keep tight under ordinary conditions. But when a considerable increase of pressure occurs, forcing the door open to relieve it, the moment of the door decreases as it opens so that it operates more and more easily as it opens wider. This seems at first sight to be an insignificant detail, but as a matter of fact I have seen great annoyances caused by vertical doors, so little gas leaking from them can be objectionable either by burning and damaging the structure or by polluting the air, that the final result is to have a rigid clamp put on the door which virtually destroys its usefulness for its primary purpose even though it may not completely eliminate the leakage.

Fig. 1 shows a design of gas outlets and down-

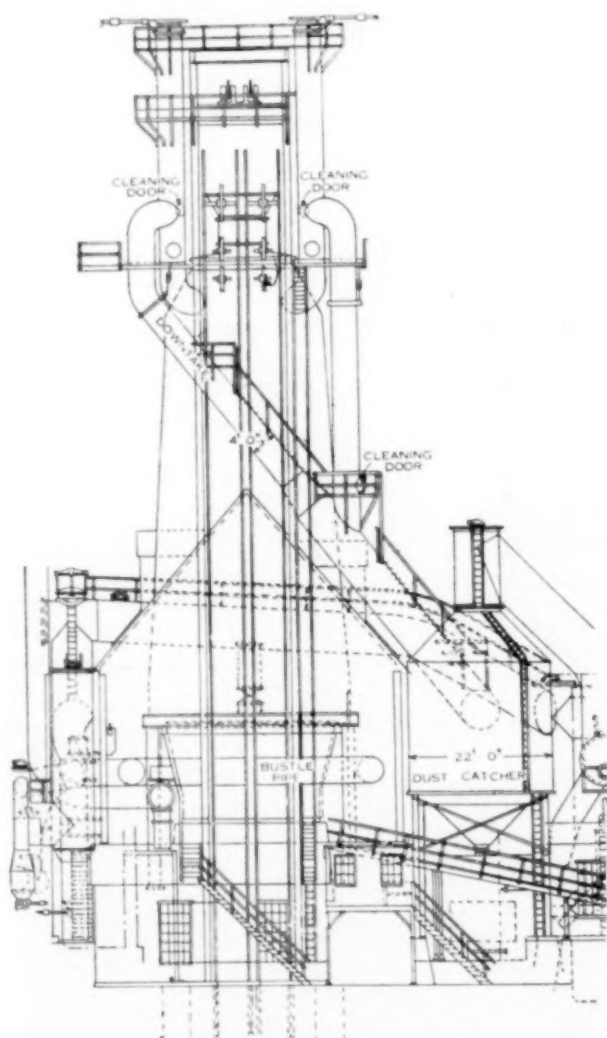


FIG. 1—ELEVATION OF BETHLEHEM STEEL CO.'S FURNACE SHOWING CORRECT DESIGN OF GAS OUTLETS

comer which secures practically all the important advantages. The drawing shows the "E" furnace of the Bethlehem Steel Company. The outlets are four in number rising from the conical top of the furnace shell. The down-comer instead of connecting directly with the outlet openings on the furnace shell on the back or high side connects with the outlet pipes at a point several feet above the operating platform and thereby secures sufficient height to give it a slope steep enough to free itself. The explosion doors are placed on the top of these high outlet pipes many feet above the operating platform and if they leak no harm

is done. If the gas burns it cannot strike anything to destroy and if it remains unburnt it pollutes the air far above the heads of those who may have occasion to be upon the operating platform.

In the early days the down-comers were made of quite thin pipe entirely unlined and these gave remarkably good service considering the relatively high temperature of the gas they sometimes had to handle, temperatures of 800 or even 1000 deg. F. in regular operation being not uncommon, while, of course, very much higher ones occurred during slips.

In modern practice, however, the down-comer is always built of very substantial steel plate and lined with circle bricks from 3 to 4½ in. thick. This makes an almost indestructible construction but a very heavy one so that due care must be taken to support the weight of the down-comer at both ends. More than one case is on record in which no better support had been provided than the conical top of the dust catcher and this has buckled under the great weight thrown upon it.

### Dust-Catchers

Dust-catchers were not considered a necessary part of a plant until within the last twenty or twenty-five years. The first ones were crudely designed, simply with the idea of providing an enlargement in the gas main in which the velocity of the gas would be reduced and its dust contents dropped to the bottom by this reduction in velocity. Ordinarily very inadequate means were provided to prevent the gas current from picking up again the dust it had once deposited, and the efficiency of the apparatus was in some cases so low that the quantity of dust recovered was inappreciable, and after several years trial the dust-catcher was thrown out and replaced by a plain section of pipe. Eventually the idea took shape of combining centrifugal force with the reduction in velocity to throw out the dust.

The sketch, Fig. 2, illustrates diagrammatically the construction which came to be standard for the first type. Fig. 3 shows an early type sometimes used to secure the centrifugal effect. The tangential inlet into the dust-catcher body constitutes the principal difference in the two types.

The difficulty of preventing the dust from being picked up by the gas current after being once deposited was a serious one and its solution was sought by several furnacemen and several designs were brought out to overcome it by having the dust impinge upon the surface of water to which it would adhere and from which the gas could not pick it up again.

One of the earliest designs to embody this principle was that of Mr. F. E. Bachman, then manager of the Northern Iron Company, at Port Henry, N. Y. Mr. Bachman built a dust-catcher in general appearance not differing greatly from the ordinary type provided with a tangential inlet as shown in Fig. 3. The shell of this instead of being lined with firebrick, as in ordinary constructions, was sprayed inside with a great number of small jets of water which produced a water film running down over this whole interior surface. Centrifugal force threw the gas against this surface to which the dust adhered and was carried to the bottom by the flow of the water film. The gas only being exposed to the surface of the water for a short time did not absorb enough water vapor to affect its thermal value materially. This dust-catcher was in operation for a number of years (as far as known to me it still is) and gave excellent results. The stoves remained clean and serviceable, although the furnace was charged exclusively with magnetic concentrates, which were quite fine.

Another design to secure this result was that of Mr. R. C. Steece, whose dust-catcher is shown by Fig. 4.

The body of the dust-catcher is horizontal and filled with water to about one-third of its height. The gas enters at one end so as to impinge on the surface of the water and is reflected therefrom into a semi-circular passage which brings it back to impinge upon the water a sec-

filled with water to a level from 4 in. to 6 in. below the bottom of the tubes. This level is maintained by overflow through the ports *H* around the circumference of the dust-catcher body.

Fresh water is introduced into the center through the pipe shown and flows regularly outward to the outlet ports *H* through which it discharges. This keeps the

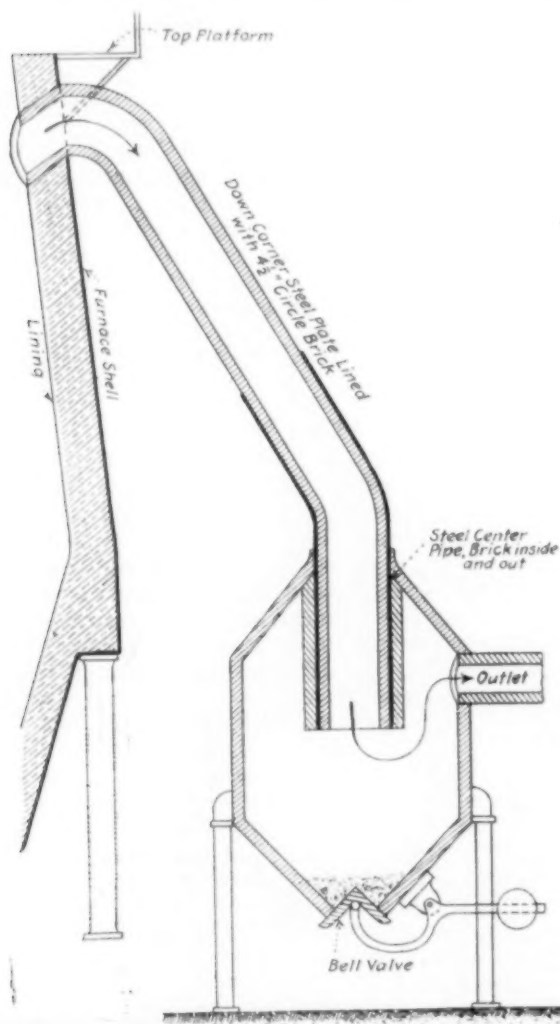


FIG. 2—TYPICAL FORM OF EARLY DUST CATCHER

ond time. A second semi-circular passage repeats the operation once more and the gas is finally discharged at the far end of the dust-catcher.

This design avoids the maintenance of the sprays required by the Bachman apparatus, but, on the other hand, the surface of the water is not constantly and rapidly renewed as it is in the Bachman design and this is a point of much importance because when the surface of the water becomes fouled by a heavy layer of dust, other dust impinging upon this is not held but liable to be picked up again and carried on by the gas.

Another dust-catcher which uses the principle of having the gas impinge upon the surface of water is the invention of Mr. B. F. Mullen, of Leetonia, Ohio. This dust-catcher has had the widest appliance of any apparatus of its type. The design is shown in Fig. 4a. The external shape of the apparatus is not unlike that of the standard dust-catcher. The gas enters at the top and passes into the central chamber shown. This chamber is suspended from the dome of the dust-catcher, its shell is lined with firebrick and its bottom constitutes a tube plate supported by the suspension rods *L*. Through the tube plate project a great number of short tubes through which the gas is forced to pass at a considerable velocity. The bottom cone of the apparatus is

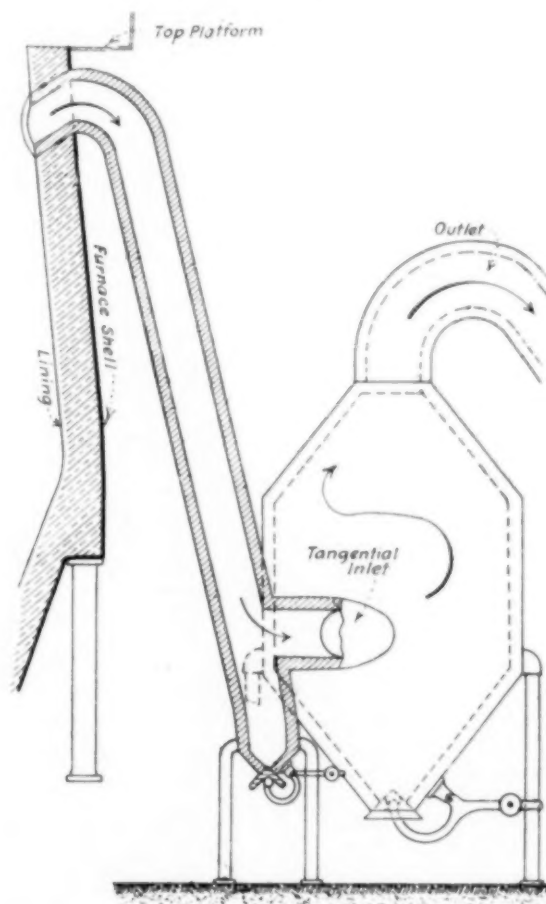


FIG. 3—TYPICAL FORM OF CENTRIFUGAL DUST CATCHER

surface of the water constantly in motion and prevents its becoming too foul to hold the dirt thrown upon it.

After the gas leaves the tubes and impinges upon the water surface it passes into the annular space around the central chamber and so to the outlet at the side. The top of the outlet trough just beneath the ports *H* is sealed by a conical plate the bottom of which is riveted to the bottom of the trough, while its top is riveted to the shell of the dust-catcher proper.

The light dust which lodges on the surface of the water is carried away by the flow of the water, while the heavy dust which penetrates the surface is flushed off from time to time through the bell valve at the bottom of the cone. A later design is modified so that the outlet trough for the waste water is inside the main dust-catcher structure instead of outside of it, but the principle remains the same.

This dust-catcher has given very good satisfaction in use. The principal point to be guarded against is any fluctuation of the water level which will permit the end of the discharge nozzles to become wet, because, if they do so the dust will rapidly build upon them and in time they will become completely obstructed. A fact not generally recognized is that flue dust has a very cement-like quality and that when dampened it sets almost as hard as a good cement. This fact has proven the destruction of the number of wet dust-catchers whose de-

signers did not know how to provide against this difficulty.

Through the courtesy of the representative of the Mullen washer I have obtained a copy of the results of a test made on one of these washers by the superintendent of one of the largest blast furnace plants in the country, with a view to finding out if the apparatus were suitable for the conditions at his plant. The results of this test showed that the gas leaving the dust-catcher contained 2.28 grains per cubic foot of dust and after leaving the gas washer it contained 0.75. The representative of the gas washer claims that it is capable of doing considerably better work than this, but even this reduces to a third the total amount of dust carried into the stoves and boilers, as there is a very considerable proportion of the total dust carried through by the stack gases without being deposited, this reduces the proportion which lodges in the stoves and boilers, to their detriment, by a considerably greater percentage, and at the original plant where this washer was installed at Leetonia, Ohio, experience proved that they could run the stoves for the whole blast without taking them off the furnace for cleaning, which would be quite impossible without some means for reducing the dust in the gas far below the percentage which it contains on leaving the dust-catcher.

Many other types of dust-catchers have been built and tried out, but these described give the broad outlines

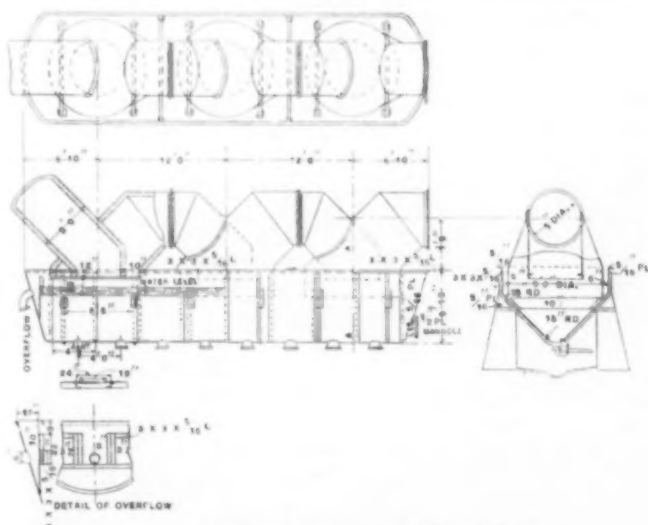


FIG. 4—STEESE AND FORD GAS WASHER

of the art as it existed before the introduction of the gas engine. This forced a further step and a very long one in the direction of cleaning the gas, and as has so often happened, knowledge of the subject gained in learning to clean gas for gas engines has proven of great advantage in directions not contemplated when the work was undertaken. There seem to be definite limits to the degree to which the gas could be cleaned by any type of dust-catcher which depends upon gravity, centrifugal force, or impact upon the water surface or combination of any of these. The degree of cleanliness so obtainable is barely sufficient for moderately good practice with the stoves, and as I have previously explained, great economies were effected by cleaning the gas a step beyond this point for use with stoves.

Most of the process used for the next step in cleaning have involved scrubbing the gas with water and this introduced another element in the situation. The gas as scrubbed picks up water vapor enough to saturate itself at the temperature at which it leaves the scrubber and this has a somewhat complicated effect. The gas as it comes from the furnace at a temperature

of 300 deg. to 500 deg. carries a very considerable quantity of water vapor picked up from the stock which in a large proportion of modern practice is heavily sprayed with water just before being charged into the furnace. This water vapor is somewhat of a detriment to the gas since it acts as ballast during combustion and prevents attainment of as high a temperature as would be reached with the same gas at the same temperature, dry. By scrubbing the gas with water this temperature is reduced and its saturation point is so much lowered that water may actually be removed from it instead of being imparted by the scrubbing operation.

It is obvious that we have here two conflicting effects. The reduction of the temperature of the gas itself is

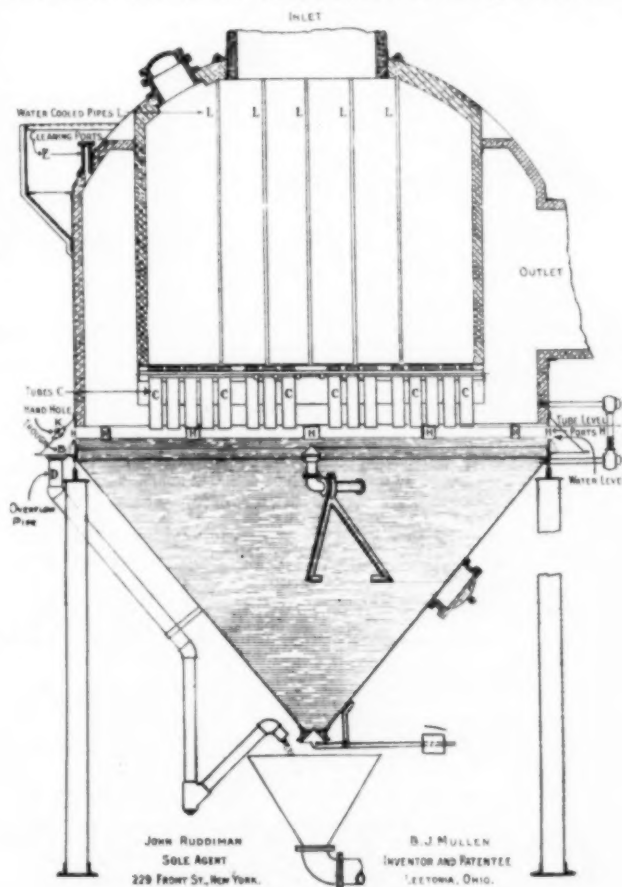


FIG. 4A—MULLEN GAS WASHER

bad because the sensible heat is an appreciable percentage of the total and if this is removed by any means before gas reaches the burners such removal represents an absolute loss. On the other hand, hot gas can carry an enormous amount of water vapor and this moisture going through the system acts as a damper on the combustion and prevents the temperature from rising as high as it otherwise would. Therefore, to remove the moisture is in itself a benefit.

There has been a certain amount of misapprehension on this subject. There have been in recent months two papers on the subject of gas cleaning, of which jointly the value probably exceeds anything published in English previous to that time. These are the papers of Mr. W. A. Forbes, "The Cleaning of the Blast Furnace Gas" before the October, 1913, meeting of the American Institute of Mining Engineers, and that of Mr. A. N. Diehl at the February, 1914, meeting of the same Institute entitled "Data Pertaining to the Gas Cleaning at the Duquesne Blast Furnaces."

From the former of these I shall presently quote extensively and from the latter also to a considerable ex-

TABLE 1.—HEAT AVAILABLE PER POUND OF DRY BLAST-FURNACE GAS UNDER VARIOUS CONDITIONS OF INITIAL TEMPERATURE AND MOISTURE CONTENT. COMBUSTION AIR CONSTANT CONDITION.

	Washed Blast-Furnace Gas at 70° F. with Moisture Saturated at 70° F. Combustion Air at 70° F. with Moisture Saturated at 57° F.			Washed Blast-Furnace Gas at 125° F. with Moisture Saturated at 125° F. Combustion Air at 70° F. with Moisture Saturated at 57° F.			Unwashed Blast-Furnace Gas at 400° F. with 35 Grains Moisture per Cu. Ft. Gas at 62° F. and 30 in. Hg. Combustion Air at 70° F. Moisture Saturated 57° F.		
	Products of Combustion Cooled to 400° F.	Products of Combustion Cooled to 500° F.	Products of Combustion Cooled to 600° F.	Products of Combustion Cooled to 400° F.	Products of Combustion Cooled to 500° F.	Products of Combustion Cooled to 600° F.	Products of Combustion Cooled to 400° F.	Products of Combustion Cooled to 500° F.	Products of Combustion Cooled to 600° F.
Total Heat Expended Above 32° F. Fuel Gas.									
Sensible heat in dry fuel gas, B.t.u. ....	9.128	9.128	9.128	22.449	22.449	22.449	99.61	99.61	99.61
Sensible and latent heat in moisture, B.t.u. ....	16.682	16.682	16.682	94.420	94.420	94.420	81.27	81.27	81.27
Latent heat of combustion, 1 lb. dry fuel gas, B.t.u. ....	1,253.800	1,253.800	1,253.800	1,253.800	1,253.800	1,253.800	1,253.800	1,253.800	1,253.800
Total, B.t.u. ....	1,279.610	1,279.610	1,279.610	1,380.669	1,380.669	1,380.669	1,434.68	1,434.68	1,434.68
Combustion Air.									
Sensible heat in dry air, B.t.u. ....	6.292	6.292	6.292	6.292	6.292	6.292	6.292	6.292	6.292
Sensible and latent heat in moisture, B.t.u. ....	7.729	7.729	7.729	7.729	7.729	7.729	7.729	7.729	7.729
Total, B.t.u. ....	14.021	14.021	14.021	14.021	14.021	14.021	14.021	14.021	14.021
Total heat expended, B.t.u. ....	1,293.630	1,293.630	1,293.630	1,394.69	1,394.69	1,394.69	1,448.70	1,448.70	1,448.70
Total Heat in Products of Combustion Above 32° F.									
Sensible heat in dry products of combustion, B.t.u. ....	144.65	183.14	228.69	144.65	183.14	228.69	144.65	183.14	228.65
Sensible and latent heat in moisture, B.t.u. ....	31.41	33.89	36.37	117.24	123.12	129.24	94.16	99.07	104.08
Total heat in products of combustion, B.t.u. ....	176.06	217.03	265.06	261.89	306.26	357.93	238.81	282.21	332.77
Heat Balance.									
Total heat expended, B.t.u. ....	1,293.630	1,293.630	1,293.630	1,394.69	1,394.69	1,394.69	1,448.70	1,448.70	1,448.70
Total heat lost in products of combustion, B.t.u. ....	176.06	217.03	265.06	261.89	306.26	357.93	238.81	282.21	332.77
Total heat available per lb. dry fuel gas consumed, B.t.u. ....	1,117.57	1,076.60	1,028.57	1,132.80	1,088.43	1,036.76	1,209.89	1,166.49	1,115.93
Total heat available per lb. dry fuel gas consumed, per cent. ....	86.39	83.23	79.51	81.22	78.04	74.33	83.52	80.31	77.03
Total heat dissipated in products of combustion, per cent. ....	13.61	16.77	20.49	18.78	21.96	25.67	16.48	19.69	22.93

tent, but both of these in my judgment give an erroneous idea as to the relative importance of removing moisture and of cooling gas. Table 2 of Mr. Diehl's paper is reproduced here as Table 1.

It will be seen that he gives calculations showing the amount of heat obtainable per cubic foot of gas under three conditions.

First—Washed and cooled to 70 deg. Fahr. and saturated at that temperature with water vapor.

Second—Washed and cooled 125 deg. Fahr. and saturated at that temperature.

Third—Unwashed at 400 deg. Fahr. and containing 35 grains of moisture per cubic foot; in other words, its natural condition as it comes from the furnace.

Three temperatures for the escaping products of combustion from the stack 400 deg. Fahr., 500 deg. Fahr. and 600 deg. Fahr., are taken for each of the three cases.

Turning now to the third line from the bottom, "Total heat obtained per pound of dry gas consumed," it will be seen that the amounts in the three cases, all at 500 deg. stack temperature are 1076.6 B.t.u. for the first, 1088.43 for the second and 1166.49 for the third. It is obvious that the most available heat is to be obtained with hot gas in spite of high content of moisture.

Mr. Diehl gives a percentage figure for the three cases in the second line from the bottom of 83.23 per cent, 78.4 per cent and 80.31 per cent. Based on these percentages he states that the dry cold gas gives the highest percentage of available heat.

This is obviously incorrect, as the highest percentage must plainly coincide with the largest absolute amount of heat obtained on any correct basis of figuring. The error has arisen by counting as available the latent heat of vaporization of the water vapor in the gas in all cases. But this is in fact not available under any known conditions of boiler or stove operation since it would require gases to be cooled far below 212 deg. to precipitate much of this moisture and recover its latent heat.

It is obvious that if the burnt gas comes in at 400 deg. and goes out of the stack at 400 deg. no loss whatever has occurred, while if it goes out at 500 deg. or 600 deg., the only loss is that in superheating this small quantity of steam 35 grains, or 0.005 lb., of water vapor, with a specific heat of 0.48 through a range of 100 deg. or 200 deg., making a loss per cubic foot of gas of only a fraction of one thermal unit.

In regard to the effect on the combustion temperature, the results are similar. The quantity of air required for combustion is about equal in weight to the gas itself, therefore the reduction of the initial temperature of the gas by a given amount results in a reduction of the temperature combustion by about one-half of that amount; to cool the gas from 400 deg. Fahr. down to 70 therefore reduces the theoretical combustion temperature by about 160 deg. The removal of the moisture tends to raise the theoretical combustion temperature but quantitatively the amount of increase is smaller than the decrease due to the loss of sensible heat of the gas, about 100 deg. against 160 deg.

When the gas comes from a furnace which does not work a wet burden of ore or wet fuel the conditions become very much worse for wet scrubbing, because in that case there is but little moisture in the gas to be removed by a reduction of the temperature and therefore such reduction represents a net loss both of combustion temperature and of thermal efficiency due to lower combustion temperature.

In the discussion of the paper of Mr. Forbes above mentioned, it was stated by Mr. S. K. Varnes, of the Pennsylvania Steel Company, that at their furnaces they had introduced gas washers for the stoves but that they had been forced to abandon them because of the increased moisture and decreased temperature of the gas which resulted in a decided lowering of the combustion temperature and corresponding reduction of the blast temperature that could be obtained from the stoves. On the other hand, great benefit has been derived from wet scrubbing, where wet ore is used. Thus

it will be seen that each case must be handled on its merits. Clean gas is always desirable and undoubtedly much cleaner gas will be used in stoves and boilers than we have been accustomed to in the past, but wet scrubbing should only be adopted after the most careful analysis of the conditions to see whether the net results will be beneficial or not, and if so, to what extent. There is but little use in supplying stoves with clean gas and then finding that we can get from them only lower blast temperatures than we could with dirty gas.

With this introduction I cannot do better than quote extensively from Mr. Forbes' paper as follows:

#### DUST CONTENT IN GAS

The gas leaving the usual dust catcher contains an average of from 3 to 4 grains of dust per cubic foot, and its further cleaning is accomplished in one or two principal stages, depending on the ultimate use of the gas; namely, primary cleaning and final cleaning. In primary cleaning, the gas is sufficiently cleaned for economical use in heating hot-blast stoves and for raising steam in boilers; it has been found that the best results are obtained when the dust content of the gas, after cleaning, does not exceed 0.2 grain per cubic foot. In final cleaning, the gas is sufficiently cleaned for use in gas engines, and in this case the best practice has resulted when the dust content of the gas, after cleaning, does not exceed 0.008 grain per cubic foot.

Various systems and methods are employed for accomplishing the desired results. In modern practice, the gas leaving the blast furnace is, in practically all cases, conducted through downcomer mains and then through a dust catcher of large capacity, and in some cases through two such dust catchers in series. A considerable proportion of the heavier dust is deposited at this stage. From the dust catcher the gas passes to the additional cleaning apparatus through gas mains, usually equipped with downtakes and valves for the removal of the deposited dust. The mode of treatment from this point on varies considerably, according to the opinions of the operators as to the respective merits of various systems.

#### PRIMARY DRY CLEANING

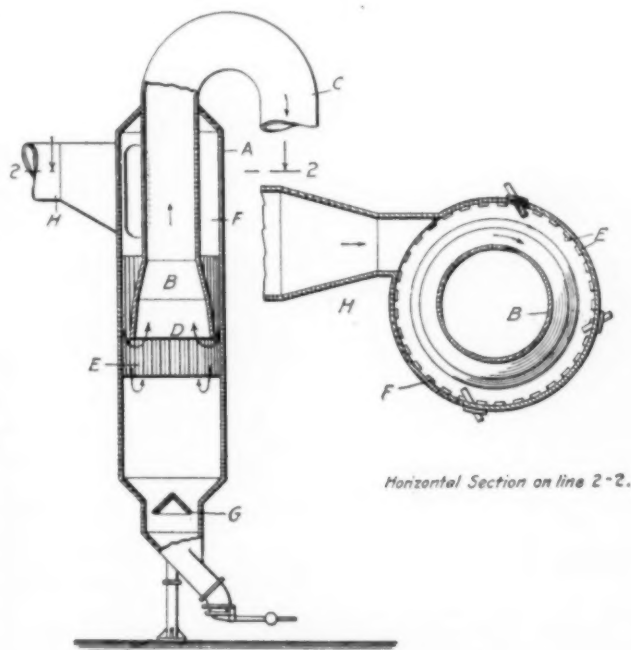
For primary cleaning, a separation of the dust without the use of water—in other words, dry cleaning—has been in favor at many plants on account of the ability to thus conserve the sensible heat of the gas, which is lost when water is used. The fact, however, should not be lost sight of that the benefit derived from the sensible heat of the dry-cleaned gas is largely discounted by the amount of water vapor in the gas. This is especially the case with gas from blast furnaces operating with a high top temperature and using ores and coke containing much moisture existing either free or chemically combined; the water vapor affects the efficiency of the combustion of the gas.

An additional benefit of dry cleaning lies in the greater facility to recover and handle the flue dust in the dry state than in the form of mud or slime in the wet cleaning processes. As before stated, the basic principles in practically all of these dry-cleaning systems depend upon a change in the direction of the gas, a reduction in its velocity, and the separation of the dust by gravity and centrifugal force. The various modifications by which this separation of dust is accomplished are all evolved from the so-called cyclone processes developed in Germany about 20 years ago. Some of these systems recently developed in the United States are the Brassert-Witting, the Roberts, the Kennedy, and the Dyblie. A description of the Brassert-Witting whirler and of the Dyblie whirler will illustrate the general principles of this type of cleaner.

#### BRASSETT-WITTING WHIRLER

As shown in Figs. 5 and 6, the Brassert-Witting whirler consists of a vertical outer cylindrical casing, *A*, and an inner inverted tube, *B*, which at its upper end is integral with the gas main *C*, which takes the cleaned gas away from the apparatus. This inverted tube is flared at its lower end, *D*; a number of iron or steel bars, *E*, are fastened vertically around the chamber *F* and extend from a point well above the lower edge of the flared end *D* of the pipe to a point well below the lower edge of this pipe. In the lower part of the chamber *F* is placed a cone, *G*, which allows the separated dust to enter the outlet pipe.

The gas enters the apparatus tangentially through



FIGS. 5 AND 6—VERTICAL AND HORIZONTAL SECTIONS OF BRASSETT-WITTING WHIRLER

the flue *H* and is given a rotary whirling motion through the annular space between the pipe *B* and the wall of the chamber *A*. On coming in contact with the bars *E* the dust is caught in the channels between these bars and is held in position by the combined action of centrifugal force and friction. As the gas continues to rotate within the annular spaces above mentioned, its velocity is gradually increased by the action of the flared end of the receiving pipe until when it reaches the lower edge of the end its velocity is at a maximum. On passing below this edge, the velocity is constantly decreased, the direction of the gas is changed and it passes upwardly through the flared end of the pipe to the outgoing gas main *C*.

The dust which has been caught in the channels between the baffle bars drops vertically into the bottom of the chamber, past the cone *G* and into the outlet pipe, whence it is removed as desired.

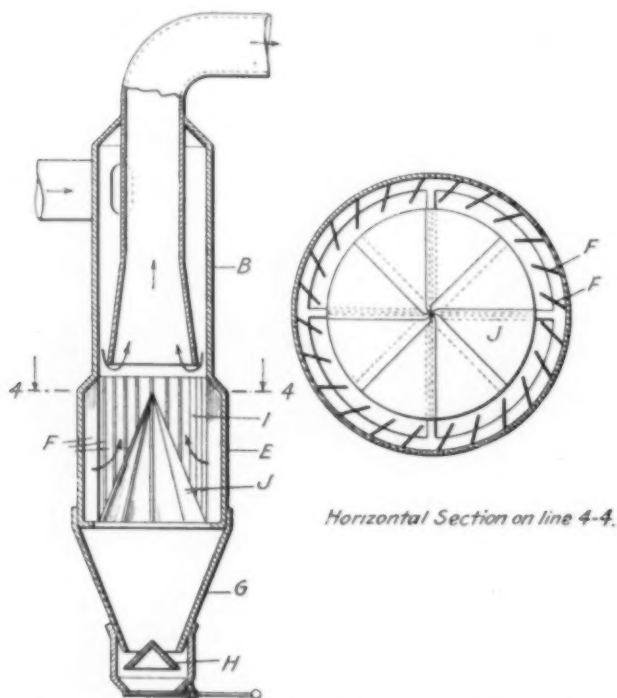
#### BRASSETT MODIFICATIONS OF BRASSETT-WITTING WHIRLER

In the Brassert modifications of the Brassert-Witting whirler, a sketch of which is shown in Fig. 7, the lower portion of *E* of the casing is larger in diameter than the upper portion *B* and is provided with a series of inwardly projecting baffle plates, *F*. The lower portion *G* of the casing *E* is cone-shaped and constitutes the dust-receiving chamber. In the bottom of this chamber is a cone, *H*, whose function is to direct the dust

toward the periphery of the dust outlet pipe. Within the chamber *I* another cone, *J*, is located and this cone is provided with a series of baffles, which are arranged as shown in Fig. 8.

In Fig. 9, which is a further modification, a spiral, *L*, is provided for the purpose of directing the flow of the gas. The lower end of the outlet pipe is made barrel-shaped. The outer casing *M* in its lower portion *N* is supplied with the baffles *O*, which instead of being mounted on the casing are bent inwardly therefrom, thus forming the apertures *P* (Fig. 10). The section *N* of the casing is inclosed by an outer casing, *Q*, thus forming the annular chamber *R*, in which partitions *S*

In the accompanying sketches, Fig. 11 is a vertical section through the Dyblie whirler and Fig. 12 is a horizontal section. The gas enters tangentially from the gas main through the opening *A* in the shell of the casing; the gas impinges upon the first turn of the spiral *B* and follows the turns of the spiral. A separation of dust from the gas occurs through centrifugal force, the particles of greatest specific gravity being thrown outwardly and falling by gravity to the bottom of the casing. At the point *C*, an increased area is provided between the spiral and the central chamber, which causes a decrease in the velocity of the gas, thus allowing a further separation.



FIGS. 7 AND 8—VERTICAL AND HORIZONTAL SECTIONS OF BRASSERT MODIFICATION OF BRASSERT-WITTING WHIRLER

are placed to prevent whirling of the gas in this annular chamber.

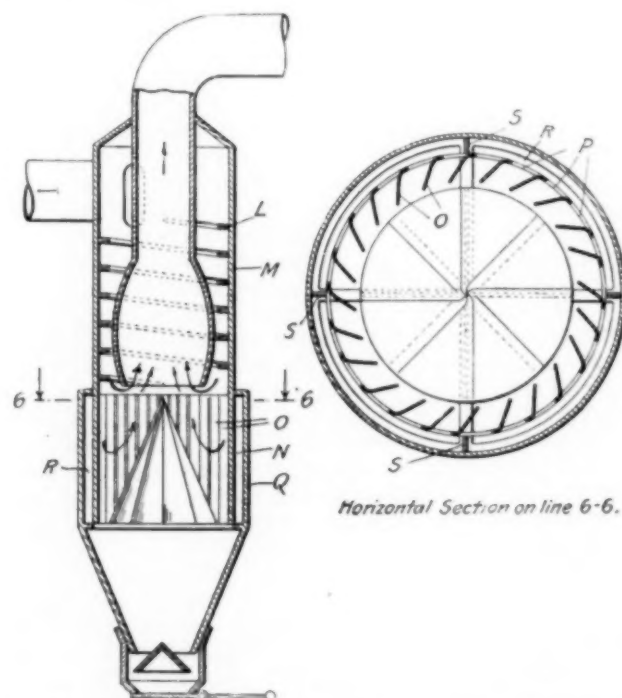
The gas is introduced and discharged and the dust is separated in a similar manner to that mentioned in the description of the Brassert-Witting whirler.

#### DYBLIE WHIRLER

In this whirler, as in most of these types, the separation is accomplished by combined centrifugal force and the action of gravity. One of the principal features in this particular whirler is the arrangement in the spiral separator of the entrance and exit openings in substantially the same horizontal plane, obviating the necessity of the gas changing its direction of flow at a sharp angle.

Described in general terms, this separator consists of a spiral conduit, the lower open edges of which connect with the dust-collecting chamber. The gas is introduced tangentially and follows a spiral course toward the central axis of the apparatus, the spiral conduit being increased in area before the gas enters the central chamber, prior to its exit from the apparatus.

The dust is separated from the gas by centrifugal force and gravity, and falls through the lower open edges of the spiral into the dust-collecting chamber. The central chamber is provided with a small opening at its lower end, and connects with the innermost spiral of the spiral conduit.



FIGS. 9 AND 10—VERTICAL AND HORIZONTAL SECTIONS OF BRASSERT MODIFICATION OF BRASSERT-WITTING WHIRLER

The inlet *A* and the outlet *D* are in substantially the same horizontal plane, and this permits the separated material to drop out of the whirling gas and prevents its being caught up in the vortex, which happens when a sudden change in the direction of the flow of the gas occurs.

A deflector, *E*, located at one edge of the opening, is provided. This is in the shape of a hook, which acts to catch any dust which might be carried into the casing, and this completes the separating operation.

#### REMARKS ON EFFICIENCY OF DRY CLEANING

It has been demonstrated in practice that dry cleaning by anyone of the systems so far referred to, cannot be depended upon by itself to continuously clean the gas from blast furnaces using much fine ore, to the degree desired for use in stoves and under boilers, the amount of dust remaining in the gas ranging from 1 to 3 grains per cubic foot, depending on the working of the blast furnace. Such systems have a value, however, in removing, by simple apparatus and at practically no operating expense, a certain proportion of the dust and so decreasing the duty upon any apparatus installed for further cleaning.

The above remarks on dry cleaning refer in no way to the Halberger-Beth system, recently developed in Germany, which will be treated separately later on.

(To be concluded.)

## Quantitative Blowpiping as an Aid to the Prospector

BY SIEGFRIED FISCHER, JR.

### Introduction

It has been the writer's pleasure to attend one of the most interesting courses given in a metallurgical department of a university. At Lehigh University, South Bethlehem, Pa., Dr. Jos. W. Richards gives a course on quantitative blowpiping which to my knowledge is unique in this country. Its importance and value struck me at once, as it would be a godsend to the prospector. With some patience and good will the average scientifically educated prospector could become proficient in the manipulation of the operations so that he could save money which he now spends, in many cases uselessly, for having assays made on all materials which to him seem of value. But that is not the only saving.

When one wishes to make his own assays, a portable assaying outfit is necessary. This involves quite an expense and the outfit is not the easiest thing to transport from one place to another. When one realizes that the minimum apparatus necessary to perform an assay by means of a blowpipe analysis can be carried in a cigar box, and that its initial cost is about one-tenth of that of a portable assay equipment one can readily observe that there is a decided gain in its use.

The average prospector desires first of all to know whether or not his ore bears values such as gold and silver. Then if so, whether it is there in sufficient amounts to justify its working. The simplest quantitative blowpipe outfit will tell him that, if he is able to use it. With a more elaborate equipment he is enabled to attain results as close as any assayer. Such metals as gold, silver, copper, cobalt, nickel and mercury can be determined with a high degree of accuracy.

Dr. Richards has devised various means to simplify the work both in apparatus as well as in methods which I will describe in the course of this paper. My main endeavor in this article is to outline the methods used for the most important metals and to bring before mining institutions situated in localities where prospecting for these metals is carried on to-day, a course, which, if given in a summer school, would enable men outside of the institution, interested in prospecting work, to become more proficient in their field. As a course for metallurgical students it has another advantage, namely, that of performing metallurgical operations on a small scale.

With this outfit all work can be handled to show a prospector whether or not the ore he is considering is worthy of closer investigation or not. He can by this means save both money and time, as it always takes several days, and at times weeks and months, before he gets the "returns" from the assayer.

I have seen Dr. Richards complete a gold and silver assay in twenty minutes. Of course, he is an expert in this line of work, but the average working time which I have observed in the class was between one hour and one and one-half hours, the class numbering eight men. I myself have completed Au-Ag-Cu assays within this time limit and a speiss containing Fe, Co, Ni, Cu, Au and Ag within two and one-half hours. Mercury ores can be easily finished in 10 minutes.

With a few additions to the equipment mentioned, we may check up our results or obtain greater accuracy. Greater accuracy may at times be attained by weighing the Au and Ag buttons. For this purpose a portable assay balance may be used. This increases the expense of the outfit, but it insures the correctness of the

### GENERAL

#### Simple equipment:

1 Pocket assay balance.....	\$16.50	\$17.50
1 Anvil .....	0.40	
1 Plattner's blow pipe, with removable platinum tip.....	2.50	
1 Charcoal borer .....	0.75	
1 Natural charcoal, per 10.....	.50	
1 Set porcelain dishes .....	0.35	
1 Dropping bottle for nitric acid.....	0.15	
1 Plattner's platinum tipped forceps.....	2.00	
1 Form for paper cylinders.....	0.15	
1 Plattner hammer .....	0.60	
1 Ivory spoon .....	0.25	
1 Magnet .....	0.10	
1 Magnifying glass .....	1.50	
1 Agate mortar with pestle.....	1.70	
1 Mortar (Diamond Lead's).....	2.00	
1 Pliers for buttons.....	0.75	
1 Plattner's ivory scale .....	3.00	
1 Alcohol lamp .....	\$0.30-	0.40
1 Scissors .....	0.50	
1 Cupel holder with 2 molds and 1 stamp.....	1.70	
1 Test lead measure .....	0.50	
6 Small test tubes .....	0.12	
1 Horn scoop, small .....	0.25	
6 Two ounce wide mouth bottles, Screw capped for chemicals	0.25	
1 Box (wood) for bone ash.....		1.25
Silver foil, per 25 gm.....		0.50
*Fairly hard melting glass tubing, 8 mm inner diam.....		0.15
2-6 Candles .....		0.25
Chemicals: Boric acid (cryst.), per lb.....		0.12
Litharge, per lb.....		0.25
Borax glass (fused), per lb.....		0.40
Test lead, granulated, free from silver, per lb.....		0.25
Sodium bicarbonate, per lb.....		0.18

results. Such balances are of greater bulk, but there is no difficulty in devising means for combining these with the rest of the equipment into one unit. Such a balance may be had from one laboratory supply compound at a price of \$70.00, being 8½ inch x 5 inch x 9½ inch in case, and having a sensitiveness of 1/100 milligram. Another balance furnished by the same company is the Nixon Portable Assay Balance; size 11 inch x 2 inch x 1 inch; cost, \$20.00. Other firms have other makes, probably just as efficient as these.

Dr. Richards has devised a scale of alloys of gold and silver. These alloys are based on the percentage of silver in them, and the sample under investigation is compared with the colors of the alloys on the scale, one of which it will match. That will give the per cent of silver in the Au-Ag alloy and the rest is gold. This little button is usually flattened out on the anvil first, between two layers of filter paper to insure a bright surface. The accuracy is not very great, the silver content being given only for 1 per cent at a time and, as with all color comparisons, it depends on every individual's ability to match them. However, in many cases where absolute accuracy is not in question, this scale offers a very rapid and simple means to obtain approximately close results. A scale of this type contains thirty-six samples of gold-silver alloys, containing 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 22, 24, 26, 28, 30, 32, 34, 36, 38, 40, 44, 48, 52, 56, 100 per cent of silver respectively.

Another apparatus of Dr. Richards' is his scale for measuring the buttons and obtaining the gold and silver. Two metal strips are fastened so that they touch at one end and diverge towards the other end. This forms a groove in which the button is rolled and measured. The right metal plate is graduated into 100 equal parts, and the groove is of such width that it gives the diameter of the button measured in one-hundredth of a millimeter. With this scale goes a table worked out by Dr. Richards himself, giving for each of the 100 divisions the weight of the gold button in milligrams, the weight of the silver button in milligrams, the volume of the button, the per cent Ag of the Au-Ag button, and the specific weight corresponding to the alloy. The use of this scale will be elucidated under the gold and silver assay.

With few exceptions, little need be said about the other apparatus in the equipment. However, it will pay to lay some stress on the Plattner ivory scale for the measurement of the gold and silver. It is constructed on the principle that buttons of silver or gold

obtained by cupellation vary in size proportionally to their weight, and that these weights are proportional to one another and also proportional to the cubes of the diameters.

One is enabled to measure these diameters between two converging lines.

To get the scale Harkort and Plattner took the silver buttons of an ore, which on a muffle assay and a blow-pipe assay showed 3.48 per cent Ag. They determined then the position of the best-formed button, obtained by cupellation, between the two converging lines, and this gave the division designated as 50. Dividing the stretch on the scale from the point at which the two lines meet to the point 50 into fifty equal parts, they obtained the left side of the scale. The convergence for a length of scale of 156 mm should be 0.09 mm. The right-hand figures give the per cent Ag by weight, if 100 mg of material were used for the assay.

Experience has shown that one can determine the weight of a silver button more accurately on the scale if it lies between 0 per cent and 0.45 per cent than it can be done on a balance. Above 0.45 per cent the balance is more accurate. Fig. 1 shows the Plattner scale.

To use this scale, the button obtained by cupellation is carefully cleaned. Care should be taken not to change its shape by any exertion of pressure, etc. It is then picked up in a pair of forceps, carefully put between the two converging lines and pushed along until both lines are just tangent to the edges of the button. To get correct readings one should use a magnifying glass. Repeated readings should be made. As the button is round great care must be taken in its handling, to prevent it from rolling off the scale and being lost. If the button lies between two of the horizontal divisions, the following should be observed: if it lies approximately half way between the two divisions, the numerical sum of these divided by 2 will give close enough results. If, however, the button is closer to one than the other one must then gauge by the eye.

As already mentioned, the numbers on the left-hand side of the scale give the weight in milligrams, if 1 decigram is used for the assay. If we now remember that there are 29,166 66/100 troy ounces in a ton of 2000 lb., and that in an assay ton = 450.09992 gr. troy there are 29,166 66/100 mg, then we see that if an assay ton were used for an assay, instead of 1 decigram, then each milligram of silver found would represent 1 oz. of metal per ton of ore.

Rule: To convert the milligram readings over into ounces divide the number of grains in an assay ton (450.09992) by the number of grains taken for the assay (where 1 decigram is used by 1.5432 grains); multiply the result by the weight of the button in milligrams according to the Plattner scale and the result is the number of ounces of silver the ore carries to the ton.

Example: Three grains of ore are taken for an assay.

The silver button lies on division No. 16 equal to 0.11 mg.

Required: Number of ounces of silver to a ton of ore.  
 $(450.09992 \div 3) \times 0.11 = 16.5 = 16\frac{1}{2}$  oz. of silver per ton.

But not only is the Plattner scale of value for the silver determination, but Plattner himself has worked out the values for gold on the same scale, that is, the milligrams of gold for Division No. 0 to No. 26, which is the limiting division for accuracy. The best results obtained on this scale for gold are between 0 per cent and 0.45 Au.

#### PLATTNER SCALE FOR GOLD

Div. No. on the silver scale	% gold
26	1.065
25	0.946
24	0.838
23	0.737
22	0.645
21	0.561
20	0.485
19	0.416
18	0.353
17	0.298
16	0.248
15	0.205
14	0.166
13	0.133
12	0.105
11	0.081
10	0.061
9	0.044
8	0.031
7	0.021
6	0.013
5	0.008
4	0.0039
3	0.0016
2	0.0005
1	0.00006

Among the working tools of quantitative blowpiping, this scale and Dr. Richards' modification of it are without a doubt the most important ones and the correct manipulation is of paramount importance.

The other utensils may be found in any of the many catalogs of firms handling chemicals and laboratory apparatus and their use is self-evident.

One thing of great importance, which is not named in the equipment given is the soda paper. There is, however, no use spending money for it, as it can be very readily made in the following way: Cut strips of paper about 1 in. wide. Long ordinary bond paper is as good as any, the strips having the length of the sheet. Now prepare a saturated solution of sodium carbonate. Draw each strip through this solution so as to wet both sides along their entire length. Then hang them up to dry. When dry, cut these strips into pieces 1½ in. to 2 in. long and put into a covered box until required for use.

Operations. In quantitative blowpiping, the following steps must be observed:

#### I. Preparation of the ore for assaying.

1. Grinding of a fair average sample.
2. Sampling.

#### II. Weighing out sample.

#### III. Weighing out fluxes, etc.

#### IV. Making up the charge and wrapping it in soda paper.

#### V. Working down to the desired metal or metals.

This step varies so much that each special case will be treated in detail under the individual metals.

#### VI. Determining the weight or percentage of the desired metal or metals.

This will be taken up under the separate metals.

It will not be out of place here to mention some of the fundamental things. For quantitative work the luminous flame should be used, a flame such as a candle gives. Two kinds of flames may be obtained with this flame by using the blowpipe, the oxidizing and the reducing flame.

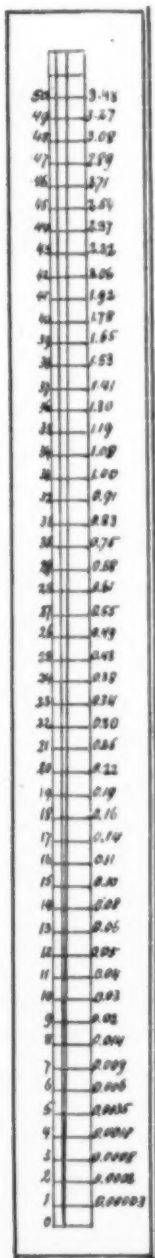


FIG. 1 —  
SCALE FOR  
MEASURING BUT-  
TONS

The oxidizing flame is obtained by putting the tip of the blowpipe into the flame and blowing rather strongly. The flame will be long, pointed and blue (Fig. 2). The harder the blowing the hotter the flame. The melting point of platinum, 1775 C., may be attained with it.

To produce a good reducing flame is more difficult than to produce a good oxidizing one. It is obtained by holding the tip of the blowpipe just outside of the flame and blowing not too strongly. A good reducing flame should be a long luminous cone, the end of which is faintly blue. The most effective part is between *a* and *d*, and the assay should be totally covered by this part (Fig. 3).

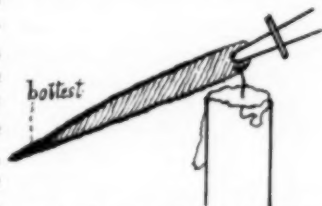


FIG. 2—OXIDIZING FLAME

In general it may be said that an oxidizing flame is used when some undesirable metal is to be slagged off and a reduction flame where it is necessary to collect metal.

As it is necessary to apply a flame steadily for quite a length of time, it is absolutely essential to know how to use the blowpipe correctly. For this purpose, rest the elbow on a table or board of convenient height, raise the forearm until vertical, grasp the stem of the blowpipe firmly with the four fingers, allowing the end nearest the mouthpiece to rest on the thumb, and press the pipe tightly to the lips. The blow should take place without stopping the natural breathing. Take a good breath of air and when the blowpipe is applied to the lips fill the space between the cheeks with air and blow. The cheeks act as bellows. When they are collapsed fill them again without stopping the breathing and continue the blowing. In this way only can a steady flame be applied for any length of time.

**Preparation of the Ore for Assaying.**—One of the most important operations is the correct sampling of the ore. Care must be taken to obtain an absolutely fair average sample of the material to be tested. It is best, of course, if the material has passed through a regular sampler, but as this is not apt to be possible for a prospector, it must be left to him to pick a fair sample.

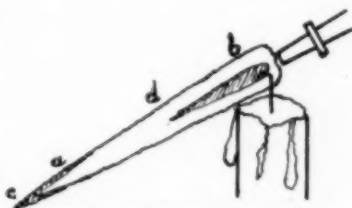


FIG. 3—REDUCING FLAME

A good scheme to follow is to take a representative sample of approximately 1 lb. of the ore, wrap it up in a cloth or several thicknesses of paper, and break it up as finely as possible with a prospecting hammer, on a flat rock, anvil or an iron plate. This done, spread the material out on a sheet of paper so that it forms a circle. With a stick divide this circle into four quadrants Fig. (4). This done, take the two diagonally placed ones (*A* and *D* or *B* and *C*) for further use and discard the rest (*BC* or *AD*). The material retained is again spread out in a circle, quartered and treated as above. Continue this operation until a sample of about 1 oz. is obtained.

This is then finely ground up in the steel mortar, and in the agate mortar until as fine as an ore used for ordinary assay work. At times a couple of sieves of small diameter (one 80-mesh and one 100-mesh) may prove useful. The sample thus obtained is put in a sample bottle and used for the assay.

**The Weighing Out of the Sample and the Fluxes.**—This, outside of the test lead, is done on the balance.

Ordinarily 100 mg of sample are very carefully weighed out. If the ore is a very poor one, 200 mg may be used, and if very rich 50 mg. This, however, holds only for silver and gold ores. It is then necessary to make corrections.

For the weighing of the fluxes the accuracy need not

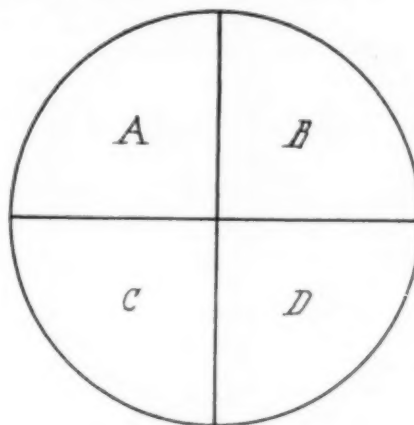


FIG. 4—QUARTERING

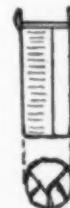
be so great, but it pays to be saving in their use. For the test lead a separate device is employed. It consists of a cylindrical piece of wood having a graduation of 5, 10, 15, and 20 on it. These divisions represent 500 mg each, or in the language of the trade 5 Zentner. Over this wooden cylinder fits a glass tube of the same length as the wooden cylinder. All according to high the glass tube is raised one can, by filling the vacant part of the tube measure out 500, 1000, 1500, and 2000 mg of test lead. The weighing out may be done by using the point of a penknife.

**Making Up the Charge and Wrapping in Soda Paper.**

—The mixing of the ore and of the fluxes is done in the little horn scoop. The ore and fluxes are put in the scoop, care being taken that all of the weighed ore is removed from the scale pan. Then they are thoroughly mixed with the end of a penknife, and if required are ready to be put in the soda paper.

FIG. 5—  
TEST  
LEAD  
MEAS-  
URE

The procedure is as follows: One piece of soda paper is wrapped around the cylindrical wooden mold, allowing a piece of the paper to overlap the end of the cylinder. This end is then closed up, as you would wrap the bottom of a round flask, and firmly pressed against some flat, hard object so as to make it stay closed. The paper cylinder thus formed is carefully removed from the mold held lightly between the index finger and the thumb of the left hand, the closed end resting on the table or some flat object. The charge is then carefully taken from the scoop and put into this paper cylinder, care being taken not to spill any. The scoop is finally brushed down into the cylinder with a small camel's hair brush. With the platinum-tipped pliers the open end of the paper cylinder is then folded over several times tightly and finally the corners are turned up to prevent the small package from opening. Its appearance will be as shown in Fig. 6. This then is ready to put on the charcoal for reduction.

FIG. 6—  
CHARGE IN  
PAPER CYL-  
INDER

Having discussed the main general features, we will deal with the special features in the next article.

## Coal Gas Residuals\*

BY FRED. H. WAGNER

A hundred years of development have passed since Murdoch lighted the city of London with coal gas, and these years have placed gas lighting in the forefront of industrial progress, while the history of these years plainly shows how the proper utilization of by-products can revolutionize the magnitude of an industry. The early years of coal carbonization could depend upon no, or but very little, assistance from by-produce sales in the matter of cheapening the cost of production, and not until the aid of modern chemistry was called in, did the production of residuals make any appreciable change in this condition.

The recovery of residuals is a very important conservation of resources, and it forms one of the principal means of revenue to the coal gas producer, the sale of these residuals reducing the cost of gas production in a degree corresponding to the efficiency of the recovery methods adopted and the market value of the product.

The principal residuals recovered to-day are tar, naphthalene, cyanogen compounds, ammonia, and, in the case of coke oven gas, also benzol by a direct recovery method, and they will be treated in this consecutive order in the following pages; the recovery of benzol is confined almost entirely to the coke-oven plant, where a direct method of recovery is adopted, and to the tar distiller, benzol being one of the most valuable of tar constituents. While the recovery of naphthalene cannot exactly be termed one of profit in a pecuniary sense at present, the removal of a certain portion from the gas is of distinct advantage, and the methods adopted for its removal will, therefore, be given.

The gas produced during the carbonization of coal is a mixture of fixed gases, vapors of various kinds, and, at times, also globules of liquids, which are held in suspension, and are thus carried forward by the gas; these gases and vapors also carry forward some solid carbon in the shape of dust.

The principal fixed gases are hydrogen,  $H_2$ ; methane,  $CH_4$ , also known as "marsh" gas; ethane,  $C_2H_6$ ; propane,  $C_3H_8$ ; butane,  $C_4H_{10}$ ; ethylene,  $C_2H_4$ ; small amounts of butylene,  $C_4H_8$ ; propylene,  $C_3H_6$ ; acetylene,  $C_2H_2$ ; carbon dioxide,  $CO_2$ ; carbon monoxide, CO; hydrogen sulphide,  $H_2S$ ; nitrogen, N; oxygen, O, and ammonia,  $NH_3$ ; while the principal vapors in the mixture are benzol,  $C_6H_6$ ; toluol,  $C_6H_5CH_3$ ; xylol,  $C_6H_4(CH_3)_2$ ; carbon disulphide,  $CS_2$ , and aqueous vapors. These latter vapors all pertain to substances which become liquid at ordinary temperatures, but the vapors of naphthalene,  $C_{10}H_8$ , phenols, etc., pertain to substances which become solid at ordinary temperatures, and must, therefore, be subjected to a special treatment.

As will be seen later, some of these constituents are of inestimable value to the coal-gas producer, and consequently the treatment of the gas after it is produced in the carbonizing plant, is of great importance; this treatment should not only consist of a method of cooling the gas, and thus condensing and precipitating the vapors as a fluid, but the method of treatment should be such as to retain in the gas those valuable illuminating constituents which may be lost to a greater or lesser extent in the usual condensing plant.

The Feld system of condensation and purification of coal gas, which embraces successive cooling with a fractionation of the products, appears most attractive from the standpoint of efficiency and simplicity.

The usual condensing system in coal-gas practice embraces the use of a primary condenser, exhauster, tar extractor, secondary condenser, and ammonia washer; the tar, together with quite an amount of illuminants, being thus removed in a greater measure by cooling, while in the Feld system, the gas is not cooled below a point where any volatile hydrocarbons are precipitated or absorbed by the effluent, the tar being fractionated in three washers into pitch, heavy oils, and middle or light oils, and the gas is treated for cyanogen compounds, combined hydrogen sulphide and ammonia,

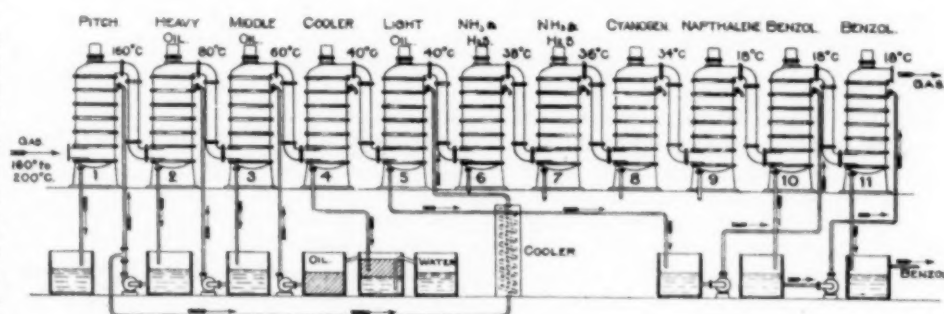


FIG. 1—FEED CONDENSING PLANT

naphthalene, and finally benzol, the entire process being carried out in Feld vertical centrifugal washers, as shown in Fig. 1.

As will be seen from Fig. 1, the entire condensing plant consists of eleven washers, the first or pitch washer operating at a temperature of from 320 deg. to 392 deg. Fahr., the gas being kept at this temperature from the hydraulic main by insulating both the main and the pipe connections, or by the application of external heat, heavy oils from washer (2) being pumped into washer (1) where they are used as the active pitch extracting medium.

Washer (2) removes the heavy oils, and it is operated at a temperature of from 320 deg. to 176 deg. Fahr., all operating temperatures being determined from the actual dew-point of the gas for the constituent to be removed, the extracting medium being the middle oils from washer (3).

Washer (3) removes the middle oils, due to contact between the gas and the oils separated by cooling in washer (4), this cooling being effected by bringing the gas into intimate contact with water, the effluent from washer (4) being run into a separating tank where the oil is separated from the water by specific gravity.

The light oils are removed in washer (5) where the gases are washed by means of heavy oils which are previously cooled in a special cooler, these oils from (5) being run into a reservoir from whence they are pumped into the first benzol washer.

The washers for ammonia and hydrogen sulphide operate under a temperature of from 104 deg. to 97 deg. Fahr. the hydrogen sulphide being combined with the ammonia in these washers with the consequent formation of ammonium sulphate, while the cyanogen washer operates at about 97 deg. to 93 deg. Fahr.

The naphthalene is removed in washer (9) at a temperature of about 65 deg. Fahr., while washers (10) and (11) serve to extract the benzol and its homologues, the partially saturated oil coming from washer (10) being pumped into washer (11).

When this paper was contemplated, it was the desire of the author to treat each residual in a more exhaustive

\*Paper read before the American Gas Institute. Copyright, 1914, by American Gas Institute. Subject to author's corrections.

manner, but owing to the large amount of data prepared the contents passed beyond the bounds of a paper of this character, and consequently it became possible to herewith present only the more essential features of residual recovery and the possible profits which might accrue due to the adoption of modern methods of operation.

## Tar

Tar is thick, dark brown, viscid, oily liquid, produced during the dry oscillation of coal; its chemical nature is very complex, and it contains a large number of compounds. The crude gas leaving the retorts is a mixture of permanent gases, but this mixture carries with it quite a number of hydrocarbons and other vapors, and as the illuminating, as well as the calorific, quality of coal gas is, in a great measure, dependent upon its hydrocarbon constituents, it is of prime importance to treat the gas so as to retain as many of these hydrocarbons as is possible. A reduction in temperature, however, soon reduces the hydrocarbons of greater density to liquid form, and this liquid is usually termed "tar." In spite of the fact that the gas temperature at the hydraulic main is perhaps never lower than 145 deg. Fahr., large quantities of tar are deposited at this point, and it is, therefore, almost impossible to retain the hydrocarbons of this class in the gas with the usual method of condensation.

Both the nature of the coal used and the temperature of carbonization exercise a great influence upon the quantity, as well as upon the quality of the tar produced, thus both quantity and quality regulating the amount of revenue received, and in this manner, governing, to a great extent, the final cost of gas production.

In the usual systems as applied at present, the removal, or the precipitation of tar, is accomplished by condensation or cooling; quite an amount of condensation occurs between the retort and the hydraulic main, a further amount of tar being deposited in the hydraulic main proper, after which the gas is conducted to the condensers where gradual cooling further reduces the tar content. After leaving the condensers, the gas still contains quite a number of tar globules in suspension, it being possible to remove only these last traces of tar by means of friction.

In the Feld system, a different method is employed as the heat contained in the gas is utilized by a system of fractional coolings

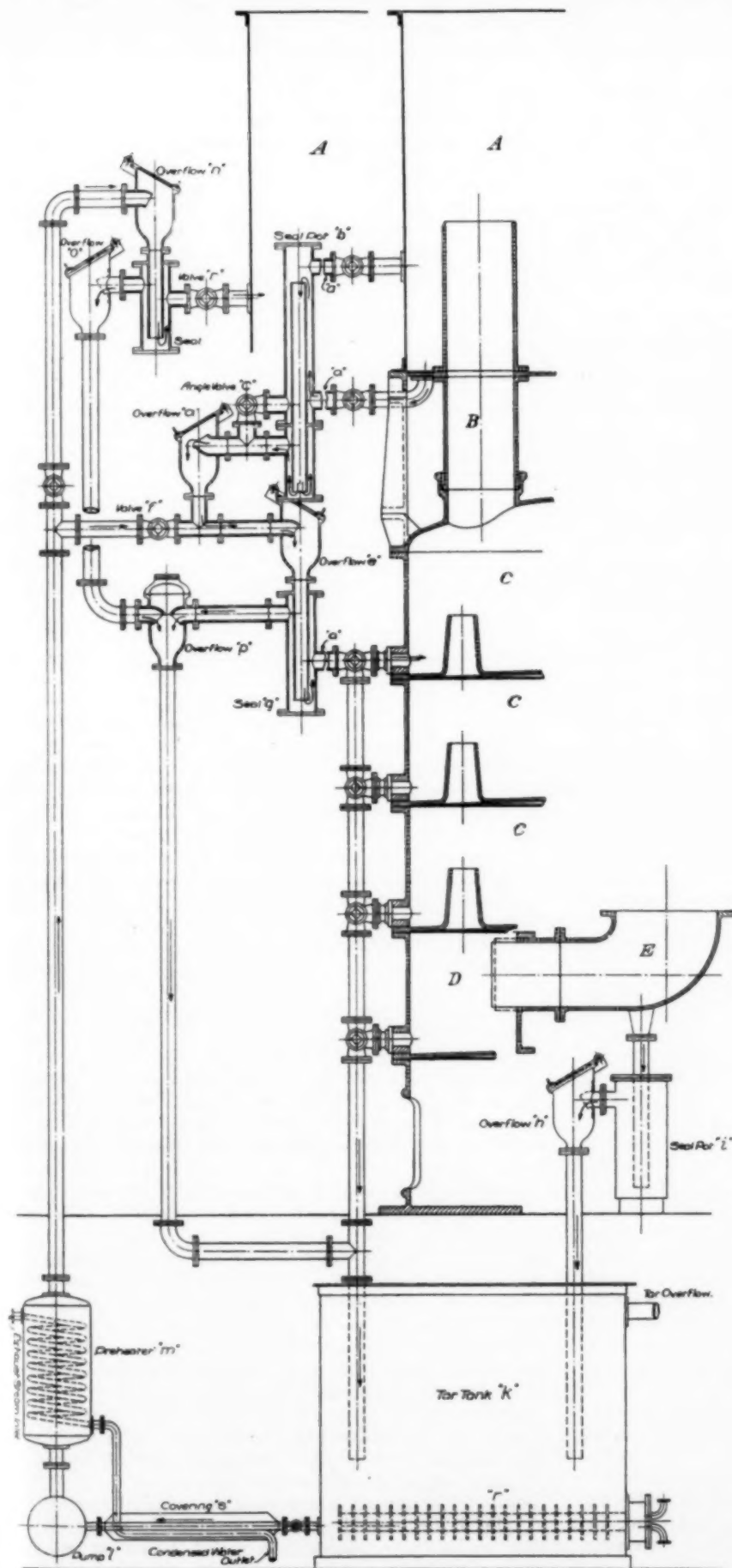


FIG. 2—FELD HOT TAR WASHER

to separate, or wash out of the gas, tar in several of its principal constituents. This treatment may also be varied in such manner as to prevent the formation of tar as much as possible by maintaining the heat of the gas coming from the retorts at a temperature above the dew-point of the gas for the constituents of high boiling points. This may be done by covering the connections from the retorts to the first washer with insulating material, or by applying heat to the exterior of the pipes. The gas thus protected is led to the washers where it is subjected to fractional cooling and successive washings at successively lower temperatures, so that the various tar constituents are separated from each other by employing the temperature of the gas itself, and without the necessity of employing extraneous heat after previous cooling.

A Feld washer especially arranged for hot tar washing is shown in Fig. 2 and in order that aqueous condensation may be avoided in the washer by reducing the temperature of the gas to the dew-point for water, the washing tar should be heated to from 40 deg. to 60 deg. Fahr. above the temperature of the gas at the inlet to the washer, this hot tar being the active tar extracting medium.

In Fig. 2, which shows a portion of a Feld washer with superimposed Pelouze condenser, *A* is a Pelouze condenser; *B*, gas port in washing chamber; *C*, upper washing chamber; *D*, lower washing chamber; *E*, gas inlet; *k*, basin, or tank containing wash tar; *r*, radiator, or steam coil; *l*, rotary tar pump; *m*, preheater for wash tar; *s*, insulated connection from tank (*k*) to pump (*l*).

In order to keep the wash tar at the desired temperature, the steam pipe from *m* is beneath pipe *s*.

The hot wash tar is pumped from tank *k* through the insulated connection *s* and preheater *m* to the Pelouze condenser *A* through the overflow pot *n*; any surplus tar overflows at *O* and *p* and returns to tank *k*.

The tar overflows from the Pelouze through *b* and *d*, *e* and *g*, into the upper chamber *C* of the washer, where it is picked up by the washing cones within the chamber and spread out over the entire gas space, the depth of the spray being from 8 in. to 14 in. depending upon the size of the washer. The gas is thus brought into intimate contact with the hot wash tar, and is subjected to a thorough washing, the wash tar as well as the tar expelled from the gas, overflowing through the gas port to the next lower washing chamber; here the wash tar is again placed in circulation by the cones in this chamber, and the total combined tar finally leaves the washer through the pot *i* attached to the gas inlet connection, and by means of overflow *h* enters tank *k*, all surplus tar from this tank flowing off to the tar storage.

In order that the maximum results may be secured, the wash tar should be constantly circulated through the washer, but it is not always necessary to circulate it through the Pelouze condenser, this omission being dependent upon the condition of the tar in the gas. The amount of hot tar to be circulated through the washer may vary from 0.5 to 2.5 gallons per 1000 cubic meters of gas per hour; larger volumes of gas require proportionally less circulating tar than do smaller volumes, but the amount of washing tar circulated must be so regulated as to prevent the temperature of the gas reducing the temperature of the wash tar.

The circulating wash tar should be pumped through the preheater *m* before it enters the washer, this preheater being supplied with a steam coil, and in some cases it may be necessary to insulate the tank containing the wash tar, depending upon its location, and even the washer proper with some insulating material, in order to increase the efficiency, as many of these washers are set up in the open in Europe, being thus exposed to the weather.

The tank containing the wash tar is also provided with a steam coil, or radiator, made in one piece in order to prevent leaks and thus mix water with the tar. Care must be exercised in operation to the extent of preventing the deposit of thick tar in the Pelouze condenser, and if the washer should be stopped for any reason, it must be emptied of tar at once in order to avoid cooling the tar and thus clogging up the passages.

Table I gives the results secured in washing with hot tar, the washer being supplied with a Pelouze condenser in the one instance, but not in the other.

TABLE I—FELD HOT TAR WASHING  
Washer Without Pelouze Condenser

Gas temperature at Inlet to Washer	Tar Content in Grains per Cu. Ft.		Grains Removed	Efficiency, per Cent	Gas passed per 24 Hrs., Cubic Feet
	Inlet	Outlet			
131° F.	11.512	0.2930	11.219	97.46	2,463,000
127° F.	10.386	0.2160	10.170	97.92	2,453,832
129° F.	10.818	0.2930	10.525	97.29	2,341,800
129° F.	13.518	0.4170	13.101	96.92	2,397,000
126° F.	9.907	0.5250	9.382	94.70	2,400,000
	Washer With Pelouze Condenser				
140° F.	10.050	0.0436	10.0064	99.56	2,600,000
194° F.	13.100	0.0872	13.0128	99.34	2,600,000

The Feld process of tar washing was installed in a works in Bohemia in 1907, and the tar was fractionated into pitch, heavy oil, and light oil, with the result that the tar produced by the old method of condensation sold for \$5 per ton, while with the use of the Feld system producing the oils direct from the gas, the equivalent of this ton of tar sold for \$16.

### Naphthalene

Naphthalene ( $C_{10}H_8$ ) is a hydrocarbon and has a melting point of 174 deg. Fahr., a boiling point of 424 deg. Fahr., and it sublimes at lower temperatures. The deposition of naphthalene in a solid state in the mains or apparatus causes many operating difficulties, as it decreases the cross-sectional area of the gas conduits and thus produces quite some back pressure on the works.

The presence of naphthalene in the gas is probably due to the high heats employed in present-day carbonization, and it is presumed that these high heats cause a partial distillation of the tar with the consequent formation of naphthalene.

The greater portion of the naphthalene produced especially with high distillation or carbonization temperatures, goes over into the tar, the gas containing only a portion of the naphthalene vapor, its maximum content being dependent upon saturation at various temperatures, but outside of the temperature of carbonization the amount of naphthalene present in the gas is also due to the character of the coal used, and upon the time of contact between the gas and hot coke and hot retort walls.

The amount of naphthalene required to saturate a gas varies according to different investigators, none of them agreeing with each other.

In order to avoid stoppages in the pipe connections due to sublimation, it would be necessary to cool the gas as nearly as possible to a temperature corresponding to that of the gas in the buried mains, but as it is almost impossible to do this during cold weather, it becomes necessary to remove the naphthalene from the gas by means of a suitable extracting medium.

The best solvents for this purpose are anthracene oil, creosote oil, and water gas tar; the tar from vertical retorts has also been used for this purpose, but this tar must first be subjected to complete cooling.

If all of the naphthalene should be removed from the gas, the latter would suffer considerably in candle-power, and no more should be expelled than what would produce sublimation with consequent stoppages.

Under ordinary conditions, 100 grains of anthracite

oil will absorb from 10 to 25 grains of naphthalene, according to temperature, but before using this oil from 3 to 4 per cent of benzol should be added, this addition leading to greater extraction efficiency, this efficiency being further increased by thoroughly and slowly cooling the gas, as the absorption is most complete at a temperature of from 60 deg. to 70 deg. Fahr.

One per cent of creosote oil will, under ordinary conditions, absorb one per cent of naphthalene, by weight, but this absorption is dependent upon the amount of phenols present.

Water gas tar will absorb from 18 to 20 per cent. of its own weight in naphthalene, this absorption efficiency also being dependent upon the amount of phenols present.

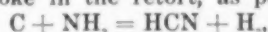
If water gas tar, or if water gas oil, is used as the absorbing medium, it can be run back to storage bearing its naphthalene burden, as the latter is not detrimental to the further use of the tar or oil, but if anthracene or creosote oil is used this oil can be regenerated for further use by being distilled and condensed, the naphthalene crystals being thus caused to crystallize out.

An attempt has lately been made to use naphthalene as fuel in internal combustion engines, and some success has been met with in this direction; the present drawback seems to be the fact that it is necessary to start the engine with gas or some liquid fuel, and to so operate it until the heat generated by the engine is sufficient to melt the naphthalene, after which the latter is fed to the engine, vaporized, and exploded. Complete success in this direction would soon open up another source of revenue to the producer of coal gas.

It may be interesting to state that a locomotive operating on naphthalene has recently been constructed in France; this locomotive is provided with four cylinders, each two cast en-bloc, 5-5-in. bore by 8-in. stroke, 70 hp being developed at 950 r.p.m. This machine is provided with two carburetors, one used on starting with spirit, and the other for the naphthalene. The carburetor used in connection with the naphthalene is cast en-bloc with the reservoir in which the naphthalene is melted, double walls for the circulation of cooling water being provided, the temperature of this water being maintained at 212 deg. Fahr., thus maintaining a constant melting temperature.

### Cyanogen

Cyanogen ( $C_2N_2$ ) is a gas composed of carbon and nitrogen, and it is probably produced during the period of carbonization in the form of hydrocyanic acid by the decomposition of some of the ammonia due to contact with the hot coke in the retort, as per the equation,



and the amount of cyanogen produced by the carbonization of any particular coal bears a certain relation to the amount of nitrogen contained in the coal.

The removal of cyanogen from coal gas is of decided advantage for two reasons, (1) owing to its corrosive effect on works apparatus; (2) because it is a valuable by-product under certain conditions; also if cyanogen is permitted to pass on into the purifiers, it will be found to enter into combination with the iron in the purifying material, thus rendering a certain portion of this iron inactive for hydrogen sulphide extraction; on the other hand, the sale of spent oxide containing a high percentage of cyanogen is more remunerative than if it contained only sulphur, as this oxide is often purchased on the basis of its "prussian blue" contents only, "prussian blue" being the name applied to this cyanogen combination.

The revenue to be derived from the extraction of cyanogen from coal gas is dependent upon the amount

of coal carbonized and upon the market price of the product, the latter fluctuating constantly; it is certainly not a remunerative proposition for works carbonizing less than 250 tons of coal per day, as the same labor expended on a plant of this size, can readily handle the proposition in one of double the capacity.

The estimated revenue in a plant carbonizing 250 tons of coal at the works, and 750 tons at another, the sludge from both being worked up in one plant, after deducting operating expenses and 6 per cent interest and 6 per cent for depreciation, amounts to \$27,935 per year, and this, without the additional revenue, to be derived by the production of ammonium sulphate from the cyanogen press liquor, this liquor being sold on the basis of concentrated ammonia. Besides this revenue, the extraction of cyanogen in this case shows an aid of 22 per cent in the action of the purifiers, or the life of the oxide is increased by 22 per cent.

The two systems of cyanogen recovery which have met with the most pronounced success, is that of Bueb, and the one devised by Feld, the former making an insoluble ferro-cyanide coke, and the latter a soluble cyanide sludge.

For a description covering the extraction of cyanogen by the Bueb process, attention is called to the paper read by Mr. M. E. Mueller during the 1910 meeting of the Institute, and which appeared in the Proceedings of that year.

The Feld process of cyanogen extraction differs from that of Bueb in that it is applied after the ammonia has been removed from the gas, this alkali being replaced with milk of lime in the copperas washing medium. The combined solution of lime and copperas is run into the Feld vertical washer, the resultant sludge coming from the bottom of the washer being boiled and then filter-pressed, the product coming from the filter press being calcium ferro-cyanide.

The product coming from either the Bueb or Feld plant, is usually worked up into potassium ferro-cyanide, and in this case the working up of the sludge produced by the Bueb system requires additional apparatus for the removal and concentration of the ammonia carried in the sludge, while the working up of Feld sludge obviates the necessity of this ammonia apparatus, as the Feld system embraces the removal of cyanogen from the gas after the ammonia has been extracted.

### Ammonia

Ammonia is a product derived from the destructive distillation of coal, and it results from the union of nitrogen with hydrogen, or  $N + H_3 = NH_3$ ; besides being an important source of revenue, the removal of ammonia from gas is necessary on account of its destructive influence on the brass and copper work of meters and gas fittings; when burned with gas it gives off noxious fumes of oxides of nitrogen.

The usual method employed for the removal of ammonia depends upon its solubility in water, and at ordinary temperatures water can absorb about 708 times its volume of pure ammonia gas, the absorption increasing with a decrease in water temperature, or

One volume of water at	32° F.	will absorb	1050 volumes of $NH_3$
"	50° F.	"	813 "
"	59° F.	"	727 "
"	68° F.	"	654 "
"	77° F.	"	586 "
"	183° F.	"	180 "

providing the pressure of the ammonia gas is equal to that of the atmosphere, and if the gas carries no tar burden.

The usual gas works method of operation, as practiced in America, removes the ammonia by condensation and washing, the first portion of the ammonia being re-

moved in the hydraulic main due to the condensation of water vapors, which thus absorb ammonia. Cooling the gas in the condensers also causes the deposition of quite an amount of water which in turn absorbs more ammonia, the final ammonia being removed in the scrubbers or mechanical washers, using as little wash water as is consistent with the result desired, viz.: strong liquor.

Raw ammonia liquor from the plant usually contains from 1 to 2 per cent of ammonia, and due to the cost of transportation, it would not, in most cases, be economical to sell this liquor in its diluted state; the raw liquor is, therefore, usually worked up for one of the following ammonia products: (1) Concentrated liquor; (2) aqua ammonia; (3) sulphate of ammonia; but the product to be recommended for any particular gas works must necessarily depend upon local market conditions.

Concentrated ammonia is a product in which the raw liquor has been freed of a large portion of water, and it is used for producing other ammonia products.

Aqua ammonia is a solution of ammonia in distilled water, a great deal of it, in a dilute solution, being used for cleansing purposes.

Ammonium sulphate is produced by distilling the liquor, and absorbing in sulphuric acid; by passing the gas through an acid bath, thus absorbing the ammonia, or by combining the ammonia in the gas directly with the sulphur radical, discarding sulphuric acid.

The working up of the liquor is usually effected in continuous stills, Fig. 3, operating with a supply of

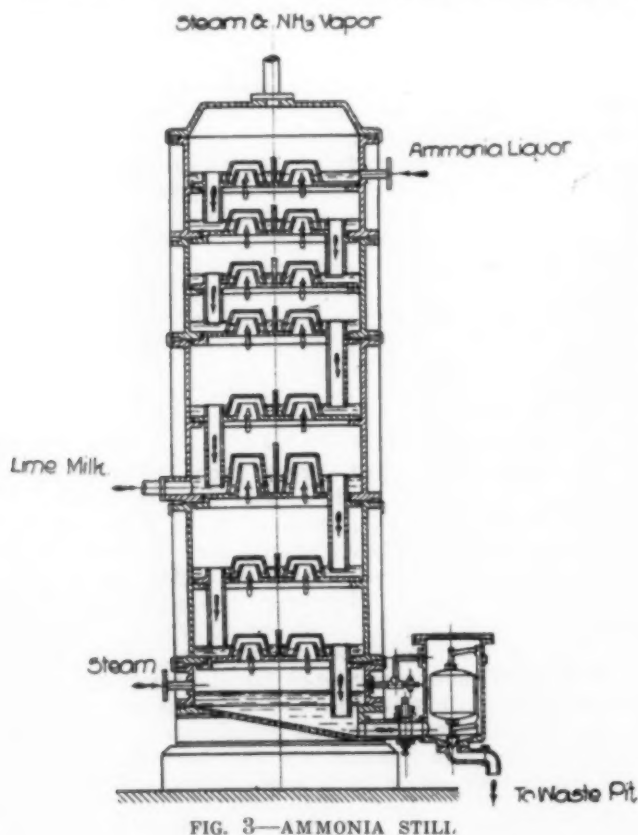


FIG. 3—AMMONIA STILL.

live steam, and as the principle of design and operation is practically the same in the usual stills on the market, only one method will be described the other differing only in detail and not in principle.

The still usually consists of a series of superimposed sections, one mounted upon the other, constructed of cast iron, each section being provided with a steam passage in the bottom, covered with a hood or bell, and an internal overflow for liquor. These sections should

be liberally provided with cleaning holes, by means of which access can be had to every part of the interior, so that the apparatus can be thoroughly cleaned without dismantling it. The liquor having been previously heated, enters at the top of the still and flows from section to section in a direction opposite to that of the steam, which enters at the bottom, passes up through the steam passages, and is caused to pass through the liquor by means of the hoods or bells.

The crude liquor is thus gradually brought to the boiling point, the free ammonia and other gases mixing with the steam in the upper portion of the apparatus. The milk of lime is introduced in small quantities into the lower or liming sections, the hoods of these sections having a somewhat deeper seal than the others, in order to permit of more efficient mixing of lime and liquor. A final boiling of the liquor in the lower sections completely liberates all of the fixed ammonia, and the stills should be so operated that the waste liquors leaving the bottom should not contain more than 0.005 per cent of ammonia.

If concentrated liquor is to be produced, the vapors coming from the still are washed in a lime washer in order to remove any carbonate of ammonia that may be formed, after which the vapors are condensed and run into storage.

The earning capacity of a concentrating plant operating in conjunction with a plant carbonizing 300 tons of coal per day, should be, with ammonia at eight cents per pound, about \$25,788 per year, or

375,000 lbs. of ammonia at 8 cents.....	\$30,000
Labor .....	\$1,830
Materials .....	1,922
Miscellaneous .....	460
Total operating cost, less interest and depreciation....	4,212
Profit per year .....	\$25,788

If the weak liquor, as produced in the works, can be sold as such, and if the ammonia in this liquor, based on the above prices of concentrate, is worth 6 cents a pound, the yearly gross revenue for this ammonia should be \$22,500, but from this would have to be deducted the added freight due to shipping a larger bulk, if the ammonia liquor is to be transported away from the works, as well as pumping charges. In order to make the sale of weak liquor a profitable undertaking as compared with concentrate, it would be necessary that an ammonia works, which would take the entire output of liquor, be established in very close proximity to the gas works.

If aqua ammonia is to be produced, the vapors from the still are sent into lime washers, coolers, charcoal filters, oil washers, caustic soda washers, and finally into the absorbers.

The earning capacity of an aqua plant of the same size as that quoted above, should be about \$47,030 per year, or

780 tons of 26° Be' aqua at \$102.....	\$79,560
Labor .....	\$3,630
Materials .....	7,610
Miscellaneous .....	21,290
Total operating cost, less interest and depreciation....	32,530
Profit per year .....	\$47,030

If sulphate is to be made from the ammonia vapors, these vapors are sent into the saturators containing sulphuric acid, where the ammonia and the acid combine to form the sulphate, and the earning capacity of such a plant of the same size as those quoted above, should be about \$30,809 per year, or

727 tons of sulphate at \$60.....	\$43,620
Labor .....	\$1,830
Material .....	10,221
Miscellaneous .....	760
Total operating cost, less interest and depreciation....	12,811
Profit per year .....	\$30,809

The net earnings of these three plants is based on 250 maximum working days.

During the last fifteen years, the attention of investigators has been turned toward an endeavor to simplify the methods used to produce ammonium sulphate from the product due to coal distillation, and instead of treating the gas liquor itself, as in the old or indirect system just described, the endeavor has been to pass the gas directly into and through the saturator, which is a closed one in this case; this method of procedure has been termed the "direct process" and, as the name indicates, it is a reversal of the old method. Other investigators have proceeded along somewhat different lines, and while passing the gas through the closed saturator, they, at the same time, vaporize the ammonia produced by previous condensation and then pass these vapors into the saturator in conjunction with the gas, this latter development being known as the "semi-direct" process.

The Feld system is even more truly a "direct process" than any of the methods mentioned above, as saturators containing sulphuric acid are not used, and when it is remembered that the production of one ton of sulphate requires approximately one ton of acid, the importance of this advanced step can be realized, Feld combining the sulphur in the gas with the ammonia, thus producing ammonium sulphate by his polythionate process, no other oxydizing agent, except atmospheric oxygen being required, and the latter is used only in the sulphur stove where the sulphur is burned to form sulphur dioxide, this sulphur stove thus displac-

ing the sulphuric acid factory which has hitherto been a necessity.

The method of operation can best be understood by following the diagram, Fig. 4. The plant is started by filling the two generator tanks *B* and *C* as well as the wash liquor tank *D* with weak ammonia liquor from the

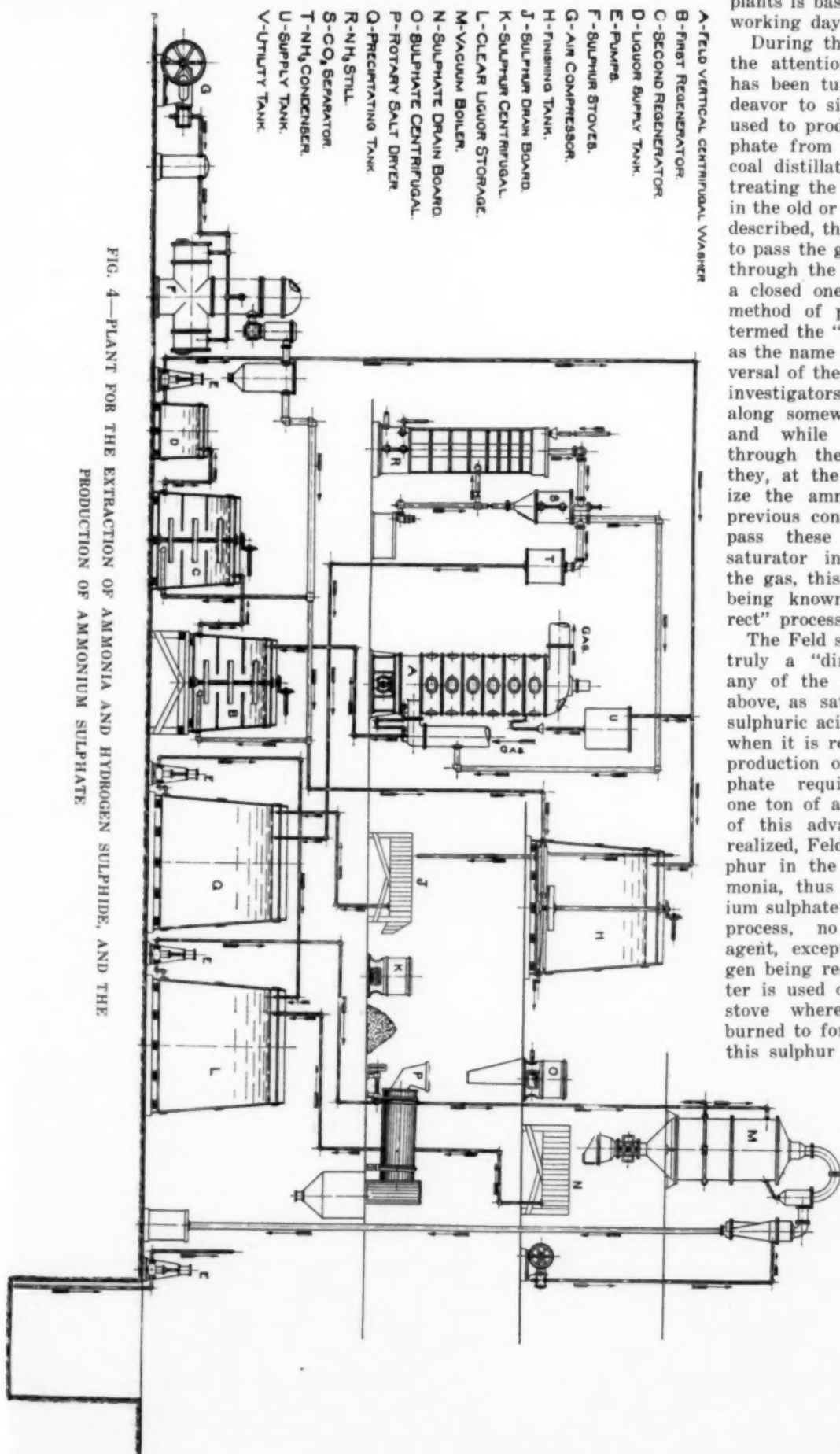


FIG. 4—PLANT FOR THE EXTRACTION OF AMMONIA AND HYDROGEN SULPHIDE, AND THE PRODUCTION OF AMMONIUM SULPHATE

works or with fresh water, this liquor or water being then pumped into the supply tank *U*, from whence it flows into the top of the washer *A*. Ammonia extraction immediately follows, and the liquor flows from the bottom of the washer as thio-sulphate, entering regenerator *B* where it is treated with sulphur dioxide coming from the sulphur stove *F*, the sulphur dioxide being forced through the liquor due to pressure produced by the compressor *G*. The overflow from regenerator *B* enters regenerator *C*, where a further treatment with sulphur dioxide is effected, and then enters the wash liquor tank *D*, from whence it is again pumped to the washer.

Alternately treating the liquor with sulphur dioxide and with crude gas forms polythionate in the first instance and thio-sulphate in the second, the polythionate being the active washing medium; an equivalent amount of hydrogen sulphide is removed from the gas in conjunction with the ammonia in the washer.

When the liquor has obtained a strength equivalent to 35 or 40 per cent ammonium sulphate, a portion of this concentrated solution is pumped into the oxidation or finishing tank *H*, it being replaced in the circulating system with weak liquor from prior condensation. In the finishing tank *H* the polythionate liquor is treated with heat through the medium of a steam coil, and some sulphur dioxide, if this should be necessary; by this treatment the thio-sulphates are transformed into polythionates which are in turn decomposed into sulphate and free sulphur.

The liquor, when decomposed, is drawn off from the finishing tank onto the sulphur drain board *J*, and the free sulphur, which is in the form of hard grains, is placed in the centrifugal *K* where its moisture is expelled; this sulphur is returned to the sulphur stove *F* for the further production of sulphur dioxide.

The liquor from the drain board *J*, as well as that from the centrifugal *K*, flows to the precipitating tank *Q*, where it is treated with some concentrated ammonia, or  $(\text{NH}_4)_2\text{S}$  from the condenser *T*; this liquor is then transferred to the storage tank *L* and is pumped from there to the vacuum boiler *M*. The concentrated ammonia, or  $(\text{NH}_4)_2\text{S}$ , from the still and condenser is sent into the precipitating tank in order that any iron held in suspension may be thrown down, thus ensuring a clean, white salt; the amount of ammonia used for this purpose is very small, but it is all recovered in the sulphate. The liquor is evaporated in a vacuum (an open evaporator may be used if desired) in the boiler, and the salts are drawn out onto the drain board *N* and from there to the centrifugal *O* and rotary dryer *P*, the salts thus produced being ready for bagging and shipping. All mother liquor from the drainboard and centrifugal returns to tank *L* and is from thence pumped back into the boiler.

The still *R* is used for the purpose of evaporating any ammonia liquor thrown down by previous condensation, these vapors being returned to the gas at the inlet to the washer, a small portion of the vapor being sent into the condenser *T* for producing the  $(\text{NH}_4)_2\text{S}$  used in the precipitating tank. The use of a still is dependent upon the method of operation; if Feld's system of hot tar extraction is installed a still will not be necessary, as there will be no precipitation of ammonia under these conditions; a still is also not necessary if the production of ammonia liquor does not exceed the amount of liquor required in circulation.

This process requires but very little expert control, the usual mechanics, attending the machinery being capable of making the necessary liquor tests after some little instruction.

The Bueb process for the extraction of cyanogen produces ammonium sulphate in solution, and therefore,

this process, in combination with the Feld explained above, forms a very remunerative proposition.

The income from such a combined plant in a works carbonizing 300 tons of coal per day is approximately as follows, based on 250 maximum days per year:

Cyanogen .....	128,500 lb. at 13.25c.....	\$17,025.00
Sulphate .....	1,349,250 lb. at 3.00c.....	40,477.50
NH <sub>3</sub> in press cake .....	29,750 lb. at 7.00c.....	2,082.50
Total gross earnings.....		\$59,585.00
The operating expenses are:		
Materials .....		\$3,695
Steam .....		1,663
Power .....		2,688
Miscellaneous .....		1,000
Labor .....		2,500
Total operating expense.....		11,546.00
Net earnings per year less interest and depreciation.....		\$48,039.00

### Benzol

While the removal of benzol from gas is not of remunerative interest to the coal gas producer under the present antiquated standard of gas sale by candle-power, it is of special interest to the by-product coke oven operator, and as all of the preceding data applies to both of these producers, the method of removing and purifying benzol, is herewith included.

Benzol is recovered from coal gas after the tar and ammonia have been removed, and all modern systems are based on the original process as carried out by Brunck in Germany in 1887. The gas is washed in a series of washers with light oil, this oil absorbing the benzol, after which the raw product is subjected to a number of distillations, producing benzol, toluol, xylol and solvent naphtha.

The Koppers Company states that the income due to the extraction of benzol from the gas produced by the carbonization of 2000 net tons of dry coal per day, is as follows:

YEARLY RECOVERY	
Benzol, 67 per cent.....	978,000 gallons
Toluol, 16 per cent.....	234,000 gallons
Xylol, 8 per cent.....	117,000 gallons
Solvent naphtha, 9 per cent.....	131,000 gallons
Total .....	1,460,000 gallons
With a gross income of—	
1,460,000 gallons at 15 cents.....	\$219,000
Crude naphthalene, 330 net tons at \$5.00.....	1,650
Regenerated acid of 40° B $\acute{e}$ , 360 net tons at \$6.00.....	2,160
Total gross income .....	\$222,810
The operating expense per year being—	
Raw material, consisting of wash oil, sulphuric acid, caustic soda .....	\$15,000
Steam for distillation, air compressor, loading pumps, acid regeneration and cooling water.....	15,000
Electric power for water pumps, oil pumps, agitator, illumination .....	6,200
Wages for three distillers and two helpers.....	5,000
Overhead expenses, fire insurance, maintenance and depreciation, assuming the cost of the complete plant to be about \$300,000.....	30,000
Caloric loss of the gas.....	13,000
Total operating expense.....	\$84,200

giving a net profit of \$222,810 — \$84,200 = \$138,610, or 46 per cent on the investment capital, and making the cost of producing one gallon

\$84,200

1,460,000 = 5.8 cents.

This profit is, of course, dependent upon the selling price of benzol and the cost of raw material.

The Bartlett Hayward Company, Baltimore, Md.

**Recording Liquid Meter.**—The Duquesne Light Company, of Pittsburgh, Pa., will employ two 300,000-lb. per hour Lea V-notch recording liquid meters of the Yarnall-Waring Company, of Philadelphia, Pa., for the measurement of condensate in their Brunots Island power plant. The Duquesne Light Company having previously installed three meters of the same capacity, now uses therefore five Lea recording meters for measuring the flow of water at the rate of 1,500,000 lb. per hour.

## Niagara Falls Meeting of the American Electrochemical Society

The twenty-sixth general meeting of the American Electrochemical Society was held on October 1, 2 and 3 at Niagara Falls. It was very well attended and favored by ideal weather. The arrangements, made by the Niagara Falls members of the Society, under the leadership of President F. A. Ladbury, were excellent and the whole meeting was a most enjoyable affair in its social functions and thoroughly successful in its professional features; the most novel and brilliant of the latter being the symposium on experimental electric furnace work on Saturday.

The total registration was well above 200.

The following is a complete alphabetical list of those who registered at the meeting:

Paul O. Abbe, New York; W. L. Adams, Niagara Falls, N. Y.; Geo. P. Adairson, Easton, Pa.; E. H. Acton, Quebec, Canada; T. B. Allen, Niagara Falls, N. Y.; Mr. and Mrs. W. H. Arison, Niagara Falls, Ont.; T. F. Bailly, Alliance, Ohio; A. N. Barron, Cleveland, Ohio; L. E. Barton, Niagara Falls, N. Y.; R. A. Bayard; E. H. Bedell, Chicago, Ill.; R. C. Benner, Freemont, Ohio; W. B. Bennett, Niagara Falls, N. Y.; Mr. and Mrs. W. F. Blecker, Canonsburg, Pa.; Miss Elaine Blecker, Canonsburg, Pa.; W. L. Bliss, Niagara Falls, N. Y.; E. Blough, Parnassus, Pa.; Dr. and Mrs. Wm. Brady, Chicago, Ill.; C. J. Brockbank, Niagara Falls, N. Y.; Geo. F. Brindley, New York; M. J. Brown, Niagara Falls, N. Y.; Mr. and Mrs. deCourcy Browne, New York City; A. R. Bullock; J. T. Burt-Gerrans, Toronto, Can.; Joe F. Callahan, Niagara Falls, N. Y.; C. F. Carrier, Jr., St. Louis, Mo.; A. W. Carroll, New York City; H. R. Carveth, Niagara Falls, N. Y.; H. C. Chapin, Cleveland, Ohio; L. W. Chubb, Pittsburgh, Pa.; W. R. Clymer, Cleveland, O.; H. B. Coho, New York; Edw. H. Cole, Niagara Falls, N. Y.; Miss Sarah Coleman, Jonesboro, Ind.; W. G. Collinson, Niagara Falls, N. Y.; V. G. Converse, Niagara Falls, N. Y.; F. T. Cope, Alliance, O.; W. M. Corse, Buffalo, N. Y.; Mr. and Mrs. Alfred H. Cowles, Sewaren, N. J.; Wm. A. Cowan, Brooklyn, N. Y.; G. E. Cox, Niagara Falls, N. Y.; John A. Crowley, Brooklyn, N. Y.; J. S. Crider, Cleveland, O.; R. A. Crider, Cleveland, O.; T. E. Crossman, New York City; N. Cunningham, Timmins, Ont.; Thos. L. Cunningham, Niagara Falls, N. Y.; H. M. Cushing; C. Dantszen, Schenectady, N. Y.; E. R. Dewart, Niagara Falls, Ont.; Bradley Dewey, Pittsburgh, Pa.; J. W. Dixon, Sheffield, Eng.; H. M. Doerschuk, Niagara Falls, N. Y.; J. V. N. Dorr, New York; H. L. Doyle, Niagara Falls, Ont.; C. L. Dunham, Niagara Falls, N. Y.; R. W. Earle, New York City; I. R. Edmands, Niagara Falls, N. Y.; John C. Egnin, Niagara Falls, N. Y.; R. M. Emblidge, Buffalo, N. Y.; L. S. Finch, Niagara Falls, N. Y.; E. C. Fish, Niagara Falls, N. Y.; Mr. and Mrs. E. A. J. Fitzgerald, Niagara Falls, N. Y.; R. E. Fowler, Niagara Falls, N. Y.; F. C. Frary, Minneapolis, Minn.; Mrs. P. M. French, Rochester, N. Y.; W. M. Frickes, Niagara Falls, N. Y.; Mrs. W. M. Frickes, Niagara Falls, N. Y.; A. O. Fuller, Niagara Falls, N. Y.; G. Furness, Niagara Falls, N. Y.; Miss V. M. Gallinger, Niagara Falls, N. Y.; R. E. Gegenheimer, A. E. Gibbs, Plainpoint, Pa.; J. T. Gibbons, Bauxite, Arkansas; I. K. Giles, Niagara Falls, N. Y.; H. W. Gillett, Ithaca, N. Y.; Mr. and Mrs. B. L. Glascok, Niagara Falls, N. Y.; J. B. Glaze, Niagara Falls, N. Y.; C. M. Graves, Niagara Falls, N. Y.; J. R. Griffith, Niagara Falls, N. Y.; J. J. Geraty, Philadelphia, Pa.; Donald S. Hake, Niagara Falls, N. Y.; H. M. Hall, Massena, N. Y.; C. G. Hardie, Buffalo, N. Y.; G. A. Hendrie, Niagara Falls, Ont.; Carl Hering, Philadelphia, Pa.; Alfred Herz, G. K. Herzog, Massena, N. Y.; F. N. Hicks, Niagara Falls, N. Y.; A. T. Hincley, Niagara Falls, N. Y.; E. C. Hoffman, Niagara Falls, N. Y.; J. A. Holladay, Niagara Falls, N. Y.; L. S. Holstein, A. H. Hooker, Niagara Falls, N. Y.; H. W. Hooker, Niagara Falls, N. Y.; W. S. Horry, Niagara Falls, N. Y.; Mr. and Mrs. L. E. Howard, Lockport, N. Y.; W. F. Hubley, Newark, N. J.; O. Hutchins, Niagara Falls, N. Y.; D. A. Johnson, Chicago, Ill.; L. E. Im-lay, Niagara Falls, N. Y.; J. A. Johnson, Niagara Falls, N. Y.; A. J. Jones, Niagara Falls, N. Y.; W. McCa. Johnson, Hartford, Conn.; H. T. Kalmus, Kingston, Ont., Canada; Wm. Kastner, Buffalo, N. Y.; Mr. and Mrs. H. W. Kellogg, Niagara Falls, N. Y.; J. Kelleher, Toronto, Ont.; Mr. and Mrs. Frank R. Kemmer, Niagara Falls, N. Y.; F. L. Kothen, Niagara Falls, N. Y.; H. W. Lacey, N. Tonawanda, N. Y.; W. Laib; W. E. Lambert, Niagara Falls, N. Y.; P. E. Landolt, New York; A. M. Lawson, Niagara Falls, N. Y.; C. E. Leffel, Mr. and Mrs. F. A. Ladbury, Niagara Falls, N. Y.; M. G. Lloyd, Chicago, Ill.; Fred J. Longley, Niagara Falls, N. Y.; D. A. Lyon, Pittsburgh, Pa.; G. A. B. Lyster, Niagara Falls, N. Y.; James H. Macbeth, Niagara Falls, N. Y.; J. H. MacMahon, Niagara Falls, N. Y.; J. R. MacMillan, Niagara Falls, N. Y.; Chas. G. Maier, Niagara Falls, N. Y.; W. Judson Marsh, Niagara Falls, N. Y.; J. G. Marshall, Niagara Falls, N. Y.; H. C. Martin, Niagara Falls, N. Y.; E. J. K. Mason, New York, N. Y.; F. C. Mathers, Bloomington, Ind.; M. E. McDonnell, Altoona, Pa.; Max Mauran, Niagara Falls, N. Y.; W. A. McKnight, Niagara Falls, N. Y.; J. D. McMahon, Niagara Falls, N. Y.; Mr. and Mrs. Ralph McNeill, New York; J. A. McSweeney, Niagara Falls, N. Y.; C. E. K. Mees, Rochester, N. Y.; W. G. Merriman, Lockport, N. Y.; D. R. Miller, Niagara Falls, N. Y.; John A. Miller, Buffalo, N. Y.; W. L. Miller, Toronto, Ont., Canada; J. B. Morden, Niagara Falls, N. Y.; Wm. C. Moore; Mr. and Mrs. W. R. Mott, Cleveland, O.; G. C. Mover, Niagara Falls, N. Y.; J. M. Muir, New York; John H. Nee, Niagara Falls, N. Y.; J. G. Nelson, Niagara Falls, N. Y.; A. Neubeck, Buffalo, N. Y.; Fredk. G. Newell, Niagara Falls, N. Y.; J. D. Oille, Niagara Falls, N. Y.; J. L. Osborne, Niagara Falls, N. Y.; C. R. Pafenbach, Lockport, N. Y.; C. L. Parsons, Washington, D. C.; T. A. Patterson, Niagara Falls, N. Y.; L. A. Pettibone, Niagara Falls, N. Y.; N. Petinot, Niagara Falls, N. Y.; A. G. Porter, Niagara Falls,

N. Y.; Mrs. A. G. Porter, Niagara Falls, N. Y.; A. F. Prenster, Niagara Falls, N. Y.; J. W. H. Randail, East Jordan, Mich.; Geo. R. Rayner, Niagara Falls, N. Y.; Jos. W. Richards, South Bethlehem, Pa.; E. F. Roeber, New York; Miss Marie H. Rose, Niagara Falls, N. Y.; W. Ross, Niagara Falls, N. Y.; A. J. Rossi, New York; Prof. & Mrs. G. A. Roush, South Bethlehem, Pa.; J. M. Rowland, Niagara Falls, N. Y.; D. A. Russell, Youngstown, Ohio; S. S. Sadler, Philadelphia, Pa.; Mr. and Mrs. L. E. Saunders, Niagara Falls, N. Y.; E. S. Scharf, Niagara Falls, N. Y.; H. C. Schlatter, Niagara Falls, N. Y.; C. G. Schluenderberg, Pittsburgh, Pa.; S. R. Scholes, Pittsburgh, Pa.; C. M. E. Schroeder, Rutherford, N. J.; Mrs. S. R. Scholes, Pittsburgh, Pa.; Mr. and Mrs. E. M. Sergeant, Niagara Falls, N. Y.; A. F. Shattuck, Detroit, Mich.; C. E. Skinner, Wilkesburg, Pa.; Lewis B. Skinner, Denver, Colo.; Mrs. Lewis B. Skinner, Denver, Colo.; Mr. and Mrs. A. W. Smith, Cleveland, Ohio; W. A. Smith, Niagara Falls, N. Y.; Walter F. Smith, Philadelphia; W. O. Snelling, Pittsburgh, Pa.; Mr. and Mrs. R. C. Snowdon, Niagara Falls, N. Y.; E. C. Speiden, Niagara Falls, N. Y.; E. C. Sprague, Niagara Falls, N. Y.; S. G. Stafford, Coraopolis, Pa.; F. A. Stamps, Niagara Falls, N. Y.; Aug. F. Stilleson, Niagara Falls, N. Y.; G. D. Stilson, Niagara Falls, N. Y.; C. E. Taylor, Niagara Falls, N. Y.; A. Thompson, Buffalo, N. Y.; C. B. Thwing, Philadelphia, Pa.; Mr. and Mrs. M. Toch, New York City; Mr. and Mrs. F. J. Tone, Niagara Falls, N. Y.; C. P. Townsend, Washington, D. C.; C. A. Tryon, Niagara Falls, N. Y.; R. Turnbull, Welland, Ont., Canada; F. M. Turner, Jr., Pittsburgh, Pa.; F. O. Tyler, Niagara Falls, N. Y.; L. D. Vorce, Wyandotte, Mich.; Wm. H. Walker, Boston, Mass.; Mr. and Mrs. Walter Wallace, Niagara Falls, N. Y.; Fred B. Wheeler, Chicago, Ill.; Mr. and Mrs. R. H. White, Niagara Falls, N. Y.; E. H. Whitlock, Cleveland, Ohio; W. R. Whitney, Schenectady, N. Y.; A. M. Williamson, Niagara Falls, N. Y.; R. S. Wilo, Pittsburgh, Pa.; Mr. and Mrs. J. R. Wilson, Niagara Falls, N. Y.; N. A. Wilson, Niagara Falls, N. Y.; C. A. Winder; Mr. and Mrs. Chas. Wirt, Germantown, Pa.; J. A. Yunk, South Orange, N. J.

The first two meetings for the presentation and discussion of papers were held on Thursday morning and Friday afternoon at the Clifton Hotel, the third professional session, devoted to the symposium, at the Fitzgerald Laboratories. Abstracts of all the papers and discussions are given below.

### Social Functions

On Friday evening a banquet was held at the Clifton Hotel. As a novel feature there were no after-dinner speeches, but instead a very elaborate illustrated lecture by Dr. C. E. Kenneth Mees, director of the research laboratory of the Eastman Kodak Company, on "the physical nature of color." The experimental demonstrations were charming.

Very enjoyable, too, was the excursion to Foster's Flats, on the afternoon of Thursday. This is a delightful spot near the Whirlpool Rapids, and the party enjoyed the presence of a local authority on the flora, fauna and history of the locality. The announcement in the program to the effect that "undoubtedly arrow-heads can be found in large quantities in the vicinity" was made good, some one hundred or two having been specially cast for the occasion. The trick was discovered when some arrow-heads of Acheson graphite were found.

### Excursion

The morning of Friday was devoted to an excursion to manufacturing plants.

The Acheson Graphite Company's works were first visited, where the making and pressing of large amorphous carbon electrodes and their subsequent transformation into graphite in electric furnaces were found exceedingly interesting.

The plant of the Niagara Alkali Company, much enlarged in recent years, was next visited. It is interesting in more than one respect. It is the only American plant in which potassium chloride is electrolyzed, the Billiter-Siemens & Halske horizontal-diaphragm cell being used. The output of caustic potash is chiefly sold for special soaps, but also for electroplaters' supplies, etc. The chlorine is partly worked up into bleach- ing powder, partly liquefied and sold as liquid chlorine, and partly worked up into hydrochloric acid (by com-



PHOTOGRAPH TAKEN BEFORE THE CLIFTON HOTEL AT THE

bination with hydrogen which is evolved at the cathode).

After this the party divided. One half visited the triple-plating department of the Spirella Corset Company, the other half the power plant of the Cliff Electrical Distributing Company (the old Schoellkopf plant).

### The Smoker

The smoker, a very big feature of the entertainment program, was held on the evening of Thursday at the Clifton Hotel. There were large, round, red and white badges with the inscription "Safety Last—Niagara Falls, the Home of Section Q." Mr. L. E. Saunders, president of Section Q, was in charge of the smoker and was very effective.

There was a long, continuous performance without an idle moment. Mr. J. Macbeth discussed the personnel of the local electro-chemical industry of Niagara Falls from the point of view of a street sweeper who hears many things that other people don't hear.

Mr. F. A. Lidbury lectured on what was an alleged continuation of Dr. Bancroft's work on electrolytic flames, showing the phosphorescence produced by the solution of effervescent cathartics, the deposition on cooled porcelain tubes of metals from the steam of boiling solutions of those metals and other instances of "those remarkable phenomena which had completely escaped Dr. Bancroft's notice." The lecturer explained that as Dr. Bancroft had cast aspersions in his lecture on his (the lecturer's) knowledge of his own business, a "tu quoque" became necessary.

Mr. Max Mauran whistled and there was a sketch giving a life-like presentation of the proceedings of a factory inspection, conducted by a State factory investigation committee, entitled: "Show the ladies what you got."

The parts of the ladies were charmingly assumed by Messrs. D. Stubblefield and J. Glaze, while Mr. M. Bartlett presented with authority and Mr. P. McN. Bennie with forcefulness and Scotch accent the parts of Haskell-Jones and Angus-McBullgang, respectively man-

ager and foreman of the Potash Carbide Abrasion Company of America. Messrs. R. Wilson, A. H. Hooker and A. T. Hinckley carried very naturally the parts of the workmen.

Slides, passed by the Censor—more or less personal, but all of them very amusing—illustrated the reports made by the different committees of Section Q. As an example we reproduce the Mazda Lisa cartoon from part II of the committee on advertising.

Then there were five entirely new songs, as well as all the old favorites of Section Q. They were not passed by the Censor. Hence we are only able to print one and a portion of another.

This is the song about Johnny, the plater:

"Johnny took some acetate, Johnny took some lead, Johnny took some poplar bark and stood it on its head, John added HCl until the bath was clear, But Johnny never knew why it plated out so queer.

"Johnny took some copper salt, dissolved in cyanide, And added dextrine, glue and snuff and aloe on the side, He spat in some tobacco juice and then he added beer, But Johnny never knew why it plated out so queer.

"Johnny used up fifteen volts for every gross of forks, Just as recommended in the platers' helpful talks, And other confidential hints were whispered in his ear, But Johnny never knew why it plated out so queer.

"O! Up came Banny with a supercilious air, And told him he'd been going wrong, and when and how and where, And Bennett wrote long papers then to make the matter clear, And now Johnny knows why it plated out so queer."

A portion of another song ran as follows:

"The furnace has a jolly time, Reducing tons of coke and lime, But when a carbon breaks, I guess, It makes an awful, awful mess.

"How useful is the humble cell, In breaking up NaCl, But when the diaphragm goes wrong, The Superintendent's face grows long.

"The Static is a patient beast, Abused the most and grumbles least, But when it does go on the bust, It gets most competently cussed.

"The load-peak meter is a pest, Its accuracy is a jest, It prints a great continuous lie, And when the bills come in they're high.

"The power house has an easy life, So free from troubles and from strife, It cooks up surges on its bus And sends them straight away to us.

"The abrasive's life is very hard, It grinds up metal by the yard, and carborundum is the one, The other's christened crastolon."

The smoker came to an untimely end at 11 o'clock through the heartless operation of the stringent Ontario liquor law.



MAZDA LISA  
A CARTOON FROM THE SMOKER



NIAGARA FALLS MEETING OF THE AMERICAN ELECTROCHEMICAL SOCIETY

### Base-Metal Thermocouples

President Lidbury called the first professional session to order on Thursday morning.

A paper by Professor O. L. KOWALKE, of the University of Wisconsin, discussed the constancy of base-metal thermocouples as related to the microstructure.

Five different samples of thermocouples wires were investigated and the results are given in detail in the paper. The original structure as well as the structures produced by a two-hour heat treatment at 400 deg., 600 deg., 800 deg. and 1000 deg., respectively, were studied. From the results it appears that those metals which form solid solutions with one another, give the best results, providing that the thermo-electric force is satisfactory and the melting point high.

The characteristics of solid solutions were found for the following alloys: nickel-iron, low in iron; nickel-chrome; chromium-iron-nickel; aluminium-nickel; nickel-copper; constantan; excello.

Silicon does not appear to be a desirable constituent in a nickel alloy for thermocouple material.

Any segregation of the metal has an undesirable effect on the constancy of the couple. Wires containing but one metal showed a satisfactory structure.

The paper elicited an extended discussion.

Mr. W. R. Mott referred to the fact that freshly made alloys frequently change their structure and crystallize out after having been taken from the furnace. Silicon is peculiar in another way in its thermo-electric characteristics, since deoxidized pure silicon behaves differently from silicon containing dissolved silica.

Mr. C. B. Thwing, in a written communication, said that in a former investigation of the relation between thermo-electromotive force and coefficient of expansion he met some striking exhibitions of the effect of aggregation of crystals as changed by heat upon both of these properties of certain alloys and metals, for instance, antimony. He suggested that Professor Kowalke apply the same tests to platinum thermocouples. Such couples when damaged by long use may often be restored by glowing them with a current not sufficient to melt the wire, but to reach, say, 1500 degrees. Microphotographs of the structure before and after the heating would be of great interest.

Prof. Jos. W. Richards said it was a fact that so-called standard couples which had been standardized and probably accurately standardized in the laboratory of the maker, when brought to the works and used there, sometimes show variations of from 10 to 100 degrees C. from the standardization. Mr. B. L. Glascock referred to a recent case in which four couples, supposed to have been standardized by the manufacturer, when checked against a platinum, platinum-

rhodium couple, varied from 8 to 52 degrees at 1000 deg. temperature. Mr. W. McKnight added that the couple, of secret composition, is manufactured for use at 1200 deg.

### Electrometric Titration

A paper on this subject, by Mr. HENRY ZIEGEL, of Brookline, Mass., concerns a possible technical application of the change in potential at the end point when a bichromate solution is reduced by a solution of ferrous salt.

The change in potential in a solution at the end point of a titration has been studied by several workers during the last fifteen years. Recently Hildebrand and especially Forbes and Bartlett, have studied this change in potential in the ferrous iron-bichromate titration. Under the conditions observed by the latter authors, this potential change is about 0.2 volt and even greater. The present author has been successful in applying this change in potential to the regulation of the burette stopcock in such a manner that the stopcock closes automatically when the end point of the titration is reached.

The apparatus used is similar to that of Forbes and Bartlett, with the following changes: In place of the usual galvanometer, a Weston No. 30 relay was used. Thus when the change in potential took place, immediate contact was made in a circuit having in it a telegraph sounder with a narrowed arm seven inches in length from fulcrum to tip. This sounder arm tip was connected to one side of the burette stopcock by means of a piece of fine chain. Final connection was made to the stopcock tip by a small brass cap cemented on with sealing wax. Such a device closed the stopcock, and a similar sounder was adjusted to the other extremity of the stopcock so that the latter would be opened by it.

Thus, at the initial potential in the solution to be titrated, the arm of the Weston instrument completed a circuit which opened the burette stopcock, and at the end point the change in potential caused the needle to swing a few hundredths of an inch, open the above circuit, and close the circuit containing the sounder which caused the stopcock to close. That is, the change in potential at the end point can be caused to close the burette stopcock mechanically, thus showing the first step in the accomplishment of titrations by other than manual operations.

The rapid stirring necessary was accomplished by using the elongated shaft of a cheap battery motor. This shaft was heavily platinum plated, and tipped with a deeply nicked disc of sheet platinum. This platinum formed the oxygen electrode. An ordinary form of calomel electrode was used. The galvanometer used was a rewound stock Weston No. 30 relay.

The procedure was to set the beaker containing the

bichromate in place, close the stirring motor circuit, and then close the switch controlling the two sounders. The burette would then deliver until the end point was reached, when, due to the potential change, the stopcock would be closed by the second sounder. These two sounders were actuated by the delicate Weston instrument.

The author proposes to apply this apparatus to the automatic titration of iron after the direct procedure of Hildebrand and to the titration of zinc by ferrocyanide.

In the extended discussions which followed, Prof. G. A. Roush, referred to similar published work of two other authors though the titration had not been rendered automatic by them. He thought that by the use of such automatic methods, the time for routine analytical work, for instances, in iron and steel laboratories, could be largely reduced.

Mr. Warren F. Bleeker, on the other hand, thought such methods were academic and referred to a similar method he had employed in permanganate titration using a ray of light and its effect on a selenium cell.

President Lidbury thought there were cases where electrometric titration would have considerable advantages over ordinary methods. For instance, in determining very small amounts of chlorides in water, a silver electrode as an indicator gives an accurate sharp end point. The method is very sensitive. Another application is the determination of the acidity or alkalinity of solutions containing hypochlorites.

Dr. W. R. Whitney said that if we add the measurement of electrical resistance to this scheme of measuring electrometric forces, we have quite a group of possible electrical titrations. The resistance method is, for instance, useful for determining the neutral point in acid and alkali titration.

Dr. W. Lash Miller pointed out the accuracy of the author's method. In fourteen analyses made by the author's machine the number of cubic centimeters added automatically varied between 19.50 and 19.79, while in six spot plate checks, done manually, the variation was between 19.50 and 20.39.

Prof. Francis C. Frary thought that according to the author's figures the automatic results were 0.8 c.c. less than the manual results. Prof. Roush replied that the machine can be set to shut off the titration at any desired voltage so that one can adjust the operation to check exactly with his own titration.

Prof. Richards said that the time saved by the machine in titrations in large laboratories was not negligible.

President Lidbury suggested that the author's apparatus might be used as a simple control of certain large-scale industrial operations, for instance, in cases in which it is necessary to keep the solution neither acid nor alkali, but absolutely neutral.

Mr. Bleeker agreed that the method is accurate and that it is perfectly feasible to use it, but in practice there exists a prejudice against a complicated electrical device in a laboratory where one cannot afford expert attention.

Dr. William Brady thought that while electrometric titrations might be a good thing, they were not particularly applicable in iron and steel laboratories.

Mr. G. K. Herzog suggested the use of electrometric titration of chlorides in the determination of the flow of water by the titration method in hydraulic plants.

#### Reproducibility of the Copper Electrode

In a paper by Professor FREDERICK H. GETMAN, of Bryn Mawr College, attention is called to the fact that in investigations of the e. m. f. of various concentration cells there is a frequent variation of the difference of

potential between the common metals and solutions of their salts.

While the phenomenon appears to be quite general, in no case has it been more difficult to secure satisfactory reproducibility than with copper electrodes. A study of the reproducibility of the copper electrode was therefore undertaken. The chief results are as follows:

Of the various forms of copper electrode which have been studied, that in which spongy copper is employed is the only form which is constant and reproducible.

The irregularities observed with electrodes of massive copper and with electrodes of platinum covered with an adherent deposit of copper, may be ascribed to conditions of metastability. The spongy modification of the metal is to be regarded as the stable modification under ordinary laboratory conditions.

The spongy copper electrodes were fine platinum loops covered with a deposit of spongy copper obtained by electrolyzing a neutral solution of copper sulphate at high current density.

The paper was discussed by Messrs. W. C. Moore, G. A. Roush, W. R. Mott, J. W. Richards, Francis C. Frary, W. Lash Miller, and H. C. Chapin. The condition of the surface determines the e. m. f. and it is, of course, affected by mechanical or other treatment. Mechanical treatment causes strains in the metal and these have some connection with corrosion. The possibility of impurities (for instance, sulphides and hydrogen) in the copper deposit was also commented upon.

#### Impurities in Cathode Copper

The sources of impurities in cathode copper were discussed in a paper by Mr. LAWRENCE ADDICKS, of Douglas, Arizona.

Several years ago, the author collected a large quantity of data in the endeavor to ascertain what rôle electrolyte included within the pores of the cathode body played in contamination, and many figures from the Raritan, A. S. & R., Balbach, Great Falls and Buffalo refineries were added to those available at the Chrome plant, with which he was especially concerned. The study proved to be too complex to yield conclusive results, but a number of relations were established.

Impurities in refined copper may (a) cause a low electrical conductivity; (b) result in brittleness or weakness; or (c) be a source of loss of by-products of value. The first class is represented by phosphorus, aluminium, silicon, arsenic and antimony; the second by bismuth, lead, tellurium, and selenium; and the last by silver, gold, platinum, and palladium. It is further interesting to note that class (a) forms with copper alloys of excellent mechanical properties, while class (b) is practically insoluble in copper, forming a brittle matrix around the copper grains in the cast bar.

From the refining point of view impurities may be due to (d) electrolytic deposition; (e) inclusion of electrolyte in the crystalline structure of the cathode; (f) mechanical contamination from anode slimes suspended in the electrolyte and attaching themselves to the cathode; and (g) substances entering during melting from furnace, fuel and tools, and from other outside sources. It must be remembered that the finished copper is guaranteed to run at least 99.88 per cent Cu, that it commonly does run 99.93 per cent in the melted bar and that it is very unusual to find 0.01 per cent of any one impurity except oxygen, probably as cuprous oxides in solid solution, or possibly some other dissolved gas, such as argon or carbon monoxide.

After a general discussion of the possible sources of each impurity, the author first takes up a detailed discussion of gold and silver.

Here abundant information is available, as the metal losses are always very closely watched. A very puzzling

case developed, in that at two refineries the proportionate silver losses ran about twice the gold. A careful investigation brought out the fact that at one of them and probably at the other, the assay method used gave low results for gold on account of the very small quantity present and correcting this would doubtless bring the gold up to the silver figures. As the silver and gold in the anodes all go into the slimes, the cathode losses should be directly proportioned to the anode contents,

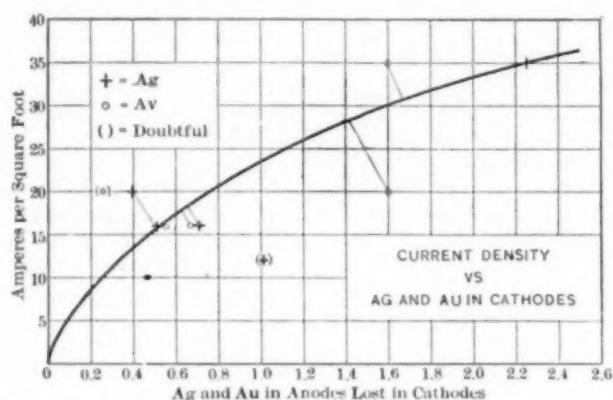


FIG. 1—CURRENT DENSITY VERSUS SILVER AND GOLD IN CATHODES

assuming an equal amount of float slimes in the different refineries. With high current densities there is more disturbance in the tank, due partly to increased circulation than when low density is used. We should therefore expect increased percentage losses at plants where high current densities are obtained.

An inspection of Fig. 1 shows that current density has directly or indirectly a marked effect on the amount of slimes reaching the cathodes. Also that for densities between 15 and 20 amperes per sq. ft. (172-215 amp, per sq. m.), comprising most of the plants (the data in this paper are all from multiple-system plants; series plants are complicated by fouling of cathodes from adhering anode scrap) some 0.7 per cent of the silver and gold in the anodes adheres as slime to the cathodes, or in other words, the efficiency of refining is about 99.3 per cent. As the silver and gold in the

Element	Per cent in Slimes	Per cent in Cathodes	Per cent Slimes X 0.000154	Remainder	Per cent Fouling by Slimes
Ag	33.82	0.00526	0.00526	0	100
Te	2.74	0.00023	0.00042	Negative	100
As	2.77	0.00105	0.00043	0.00062	41
Sb	5.46	0.00255	0.00083	0.00172	32
Fe	0.19	0.00330	0.00063	0.00327	1
Ni	4.93	0.00520	0.00077	0.00443	15
Pb	1.86	0.00079	0.00029	0.00041	41
S	2.01	0.00076	0.00031	0.00045	41

anodes all goes into the slimes, this is the same thing as saying an equivalent amount of the anode slimes is carried over to the cathodes and knowing the analysis of the slimes, we should be able to figure the degree of fouling from this source. It will be of interest to test an actual case as in Table I.

The case taken is one where the fouling as shown by the silver is twice normal, which, however, is of no harm as an example. Figures happen to be available for this period (which covers many million pounds of cathodes) for raw slimes, that is slimes that have simply been boiled free of soluble sulphates before sampling, whereas slimes are nearly always roasted and boiled in dilute sulphuric acid until practically copper-free before samples are taken and this operation somewhat disturbs the balance of impurities. The figures show clearly that except in the case of the insoluble group of elements before mentioned the slimes are not

the only source of fouling. Except for iron and sulphur, the melting operation may slightly reduce impurities, but cannot increase them, so our argument is on the safe side.

The position can be attacked, however, on the ground that silver and gold are heavy and sink readily to the bottom of the tank, while the lighter oxidized impurities chiefly make up the float slimes. Emrich, in his paper on the "Refining of Blister Copper," presented before the American Institute of Mining Engineers, in 1904, argues backwards from the cathode analysis to prove this point and concludes that practically all the fouling comes from float slimes. Mr. Addicks thinks that some of the data submitted later show that his position is not sound. It is true that material collected at some distance away in launders, etc., runs disproportionately low in gold and silver, but this is truly floating material, whereas the cathode fouling takes place but an inch from the anode and the bottom of a cathode is known to be more foul than the top.

It may also be well to point out here that satisfactory samples cannot be obtained by drilling cathodes. In the first place, individual cathodes are irregular in purity, but more important is the fact that such samples always show too low results for impurity. This is due to the fact that adhering slimes are usually the nuclei of nodules forming rough deposits and it is necessary to take a relatively smooth part of the cathode in order to drill a hole. Nodules broken off and melted will often show ten times the impurities contained by a drilled sample of the body of the cathode. For these reasons it is necessary to fall back on melted samples or fire-refined cathodes in spite of the accompanying disadvantages, when undertaking work of this character.

The next element on which abundant data are available is arsenic, the ancient, but long since subdued, enemy of copper refining. It was early found that the presence of arsenic in an electrolyte was detrimental to the conductivity of the cathodes. A table is given

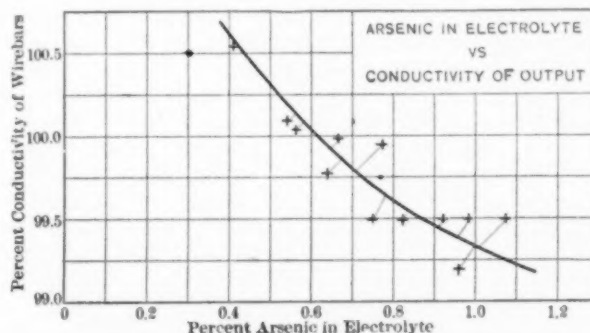


FIG. 2—ARSENIC IN ELECTROLYTE VERSUS CONDUCTIVITY OF OUTPUT

in the paper for the average monthly value of arsenic in the electrolyte and the conductivity of the wire bars of one of the refineries for a year. The figures of this table are plotted in Fig. II, which clearly shows their correspondence.

The same relation can be established by direct comparison of arsenic in electrolyte and in wire bars. In another table in the paper figures over a long range of time and for several plants, A. B. C. D., have been grouped, in some cases by periods and in some by classes. These figures plotted in Fig. 3 indicate an arsenic content in the wire bars of 0.0013 per cent when there is no arsenic in the electrolyte, which should be a measure of the fouling due to slimes. Anything above 0.0013 per cent would be due to either inclusion of elec-

trollyte or electrolytic deposition of arsenic. Included electrolyte should vary directly with the composition of the solution, other things being equal. On the other hand, electro-deposited arsenic should increase with the voltage. Now plant C runs at very high current density and therefore at correspondingly high voltage, but no corresponding increase in arsenic in the wire bars can be noticed.

The figures, therefore, might seem to indicate inclusion as the chief source of fouling above the slimes

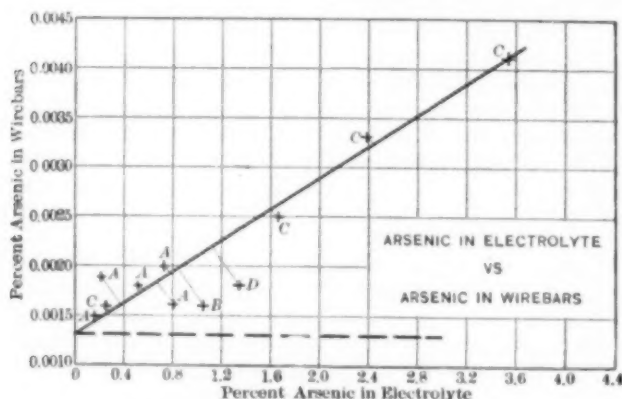


FIG. 3—ARSENIC IN ELECTROLYTE VERSUS ARSENIC IN WIREBARS

minimum. These Great Falls figures (plant C), by the way, have since been summarized in a paper by Mr. W. T. Burns, Superintendent of that refinery, presented before the American Institute of Mining Engineers last year.

We may now turn to nickel for further light on this subject. Here we have an element whose sulphate has a very high decomposition voltage and it would seem unlikely that any nickel at all, regardless of the voltage, could be electro-deposited from a strongly acid solution. Table II gives results from nickel from various sources.

TABLE II.

Plant	Representing	Per cent Ni in Electrolyte	Per cent Ni in Wirebars
A	1909	1.95	0.0041
A	1910	1.60	0.0055
A	1911	1.73	0.0066
A	1912	1.32	0.0038
A	1913	1.78	0.0037
B	10 months	0.973	0.0045
C	Rough figures	1.00	0.0016
D	1 lot	0.594	0.0014

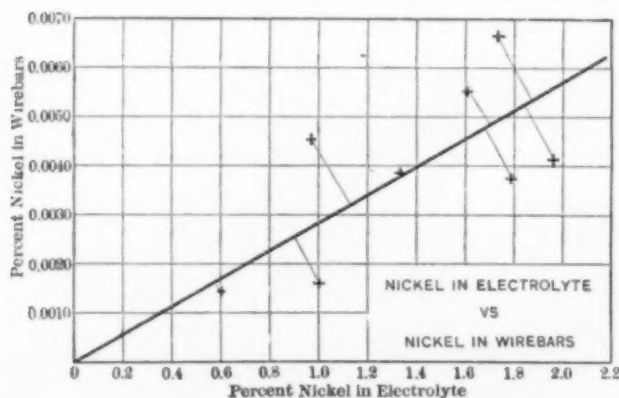


FIG. 4—NICKEL IN ELECTROLYTE VERSUS NICKEL IN WIREBARS

These figures when plotted in Fig. 4 indicate a straight line relation, as in the case of arsenic, but with no nickel in the cathodes when nickel is absent from the electrolyte. In other words, there is no fouling from the slimes. This may easily be so, as the slimes usually carry

much less nickel than shown in Table I and even there the possible fouling is but 15 per cent. Further, this nickel is probably present as nickel oxide which is slowly soluble in electrolyte and float slimes may be largely cleansed of their nickel by the electrolyte. The surprising thing, however, is the large amount of nickel found in the cathodes. While a rise of 1 per cent in the content of the electrolyte shows in Fig. 3 a corresponding rise in the wire bars of but 0.0009 per cent, in the case of nickel it shows 0.0028 per cent, or three times as much. Emrich found the same thing. He says: "The large difference shown between the calculated and the observed values of nickel in the cathodes, is a mystery which I have been prevented from investigating."

Either a large quantity of arsenic is removed in the refining furnace, or we must accept electrodeposition of nickel, as the included electrolyte must be rigidly equivalent in the two cases. Those who have tried eliminating traces of arsenic in a refining furnace, except by the use of lime and soda ash or similar fluxes, which is done only in special cases where undesirable quantities of arsenic are present, will lean toward the nickel deposition explanation.

Some laboratory experiments indicated that while no nickel can be deposited from a pure acidulated solution of nickel sulphate, traces can be found in the cathodes when arsenic is added to the electrolyte, which suggests some ion based on the known affinity of nickel for arsenic. Also in an electrolytic separation of copper and nickel by the Hybinette process where the electrolyte was very high in nickel sulphate, copper containing as much as 0.1 per cent nickel has been produced. While these conditions are far from those obtaining in a copper refinery, the results greatly strengthen the deposition argument.

Finally we can examine the inclusion argument on the basis of the specific gravity of cathode copper. If from Fig. 3 a cathode runs 0.0022 per cent, minus 0.0013 per cent (due to slime) equals 0.0009 per cent arsenic due to inclusion of electrolyte running 1.0 per cent arsenic, the cathode would contain 0.0009 times 100 or 0.09 per cent of electrolyte of a specific gravity of let us say 1.15. As copper has a specific gravity in the neighborhood of 8.9, the amount present by volume would be 0.09 times 8.9 divided by 1.15, or 0.7 per cent, which is a measure of the porosity of the cathode. The specific gravity of the copper would be correspondingly diminished, but the amount would be so slight that the known facts do not contradict it. Cathode copper actually shows a specific gravity of about 8.9 similar to worked cast copper, but, on the other hand, we know that cathode copper is very hard—experimental work on direct production of electrolytic wire has given considerable trouble from wear on the dies—and we should therefore expect to find it denser than any other copper if it were absolutely non-porous.

We therefore arrive at about where we started, believing that slimes, included electrolyte and direct deposition all have a hand in the fouling of cathodes, but without being able to assign definite values to each. The relation between arsenic and nickel in electrolyte and in wire bars does seem to be reasonably established and this is of some practical value.

In a communicated discussion, Prof. Wilder D. Bancroft suggested that the fact that nickel is deposited with the copper to an extent increasing with the concentration is probably due to the fact that copper and nickel form a continuous series of solid solutions.

Dr. W. R. Whitney commented very favorably on Mr. Addicks' paper and emphasized the enormous extent to which the electrical industry is indebted to electrolytic copper refining, because of the high economy of a high-grade copper in certain types of apparatus.

### Electro-Analysis of Nickel

The electrolytic determination of nickel was the subject of a paper by Dr. W. JUDSON MARSH, of Cornell University. The paper points out a lack of accuracy in Classen's method and describes a new method which is quite exact.

The solution is made up as follows:

Nickel present (about 0.2000 g.) as  $(\text{NH}_4)_2\text{SO}_4 \cdot \text{NiSO}_4 \cdot 6\text{H}_2\text{O}$ .

Ammonium hydroxide 15-20 cc. (Sp. g. 0.96).

Ammonium sulphate 5 grams.

Amperage  $0.8 \pm 0.1$ .

Potential difference  $3.5 \pm 0.2$  volt.

Time required about 25 minutes. Room temperature.

Nitric acid, nitrates, and chlorides must not be present. Total volume of solution made up with  $\text{H}_2\text{O}$  to 200 cc.

Electrolyze in a 350 cc. beaker using a 10-g. platinum wire gauze flag anode (52 mesh and  $6 \times 4.5$  cm.) and a rotating (550-650 r.p.m.) pure Cu gauze (50 mesh and 5 cm. high  $\times$  3 cm. diameter) cathode. This electrode combination is much less expensive than the Classen dish and disk of platinum, requiring only one-fifth as much platinum as the latter. The Cu wire gauze cathode can be made easily, quickly, and cheaply. Stiff, twisted Cu wire is used for the stems and small Cu tacks are used to rivet the gauze together. One such cathode can be used for a great many determinations, as a fresh surface for deposition may be obtained by clipping a used cathode in 1:1  $\text{HNO}_3$  for a few moments. When well made and properly handled the cathodes which cost but a few cents and a few minutes work give results exactly as good as any platinum cathode. This makes it possible to run many more determinations than is usually possible with more expensive forms of apparatus. These cathodes have also been used successfully in the laboratory for the determination of copper, tin, cobalt, cadmium, bismuth, silver, and zinc. They have also been used in combination with the platinum wire gauze anodes for the determination of lead and manganese, both of which are deposited on the anode as peroxides.

In the discussion Prof. Francis C. Frary agreed that the new method, which is a modification of that of Fresenius and Bergmann, is easy and accurate. He stated that it is not necessary to rotate the cathode.

### Quantitative Determination of Radium

Prof. HERMAN SCHLUNDT, of the University of Missouri, contributed a paper on "some experiments on the quantitative discrimination of radium."

The accurate determination of radium in radium-bearing ores is generally conducted by the emanation method. With proper care the method is very certain and delicate. It is based upon the fact that the gaseous disintegration product of radium, the emanation, can be completely separated from radioactive materials, and that the equilibrium quantity is proportional to the content of radium. The minute quantities of radium emanation concerned in quantitative determinations of this kind are capable of exact measurement by electrical methods. The emanation is introduced into an airtight electroscope or an ionization vessel connected with an electrometer, and the saturation current produced, under proper conditions, is proportional to the quantity of radium in the specimen from which the emanation was separated. The measuring instruments are standardized by means of known quantities of emanation from a standard radium solution, or from weighed amounts of uraninite or some other uranium-bearing mineral not of secondary origin, whose uranium content is known. In standardizing electroscopes by the latter

method the radium content of the mineral is obtained by multiplying its uranium percentage by the proportionality factor  $3.4 \times 10^{-7}$ .

In the assay of radium ores the complete separation of the emanation from the specimen under examination is of course absolutely essential for accurate work. The collection and subsequent transfer of the gas is largely a matter of careful manipulation. The work of various investigators has shown that heating even to a white heat rarely expels all of the emanation from solids. The emanation, however, is completely liberated from the ore by dissolution and boiling. For substances soluble in water or acids several forms of apparatus for the quantitative separation of the emanation have been described.

Rocks and minerals that do not dissolve in acids upon heating, or are only partially soluble in them, require different treatment. One of the standard methods, known as the solution method, consists in fusion of a definite quantity of the material with four to five times its weight of mixed carbonates of sodium and potassium. The fused mass is lixiviated with water and washed with dilute sodium carbonate solution. The insoluble residue is dissolved in dilute hydrochloric acid. The alkaline and acid solutions are placed in separate flasks which are corked. On standing for a month the equilibrium quantity of emanation is again produced by the radium in solution. The emanation is then separated by boiling, and transferred to an emanation electroscope, and after three hours, when the activity is a maximum, the saturation current is measured.

Recently Joly and others have introduced fusion methods which appear to be more reliable than the solution method. The emanation is released from the rock by fusing it with a suitable flux—mixed carbonates of sodium and potassium are generally used—in a closed, electrically heated furnace at a temperature of over 1000 deg. C. The liberated emanation is collected, and after being freed from carbon dioxide, is transferred to a standardized electroscope for measurement.

The results obtained by the fusion method are generally higher than the values by the solution method. In the solution method it is difficult to avoid the formation of slight precipitates in the solutions, and these doubtless cause the separation of some radium, which does not release its emanation completely upon boiling.

The author has investigated several fusion methods and his chief results are as follows:

The solution method, that is, fusion with mixed carbonates, followed by solution and boiling, gave results that are only 70 to 80 per cent of the values obtained by the fusion method with mixed carbonates.

Fusion with mixed carbonates appears to be superior to fusion with potassium acid sulphate, although with the carnotite concentrate a slightly higher value was obtained with the sulphate.

Fusion with borax probably gives low values as a result of the retention of some of the emanation in the melt. At the temperatures attained in our experiments the evolution of gas and its flow through the melt is necessary for complete release of the emanation.

High emanating power in the cold indicates a large release of emanation by heating. In the case of the specimen of carnotite ore a rough assay may be made by merely heating the ore to bright redness.

A complete separation of the emanation from uraninite is obtained by solution in nitric acid and by fusion with some of the ordinary fluxes.

Dr. S. L. Lind (of the Bureau of Mines, Denver) stated in a communicated discussion that incidental to a determination of the radium to uranium ratio in carnotites he and Whittemore studied the quantitative de-

emanation of carnotite in a large number of samples of ore by four different methods. As regard the method of fusion with  $\text{Na}_2\text{CO}_3$  and  $\text{K}_2\text{CO}_3$  mixture and subsequent dissolution and decomposition of the residues in dilute acid, they agree with Schlundt in obtaining results 10 to 20 per cent low. The method of dissolving directly in boiling 1-1  $\text{HNO}_3$  they found to give correct results, as indicated by the Ra to U ratio, and also by agreement with a direct ignition method, employing Jena glass and Meker burner, and they place the highest confidence in these two methods for this ore. With respect to the carbonate fusion method, they have failed in all carnotites to obtain anything approaching complete de-emanation which result they have been inclined to attribute to the influence of silicates on the viscosity of the melt, because they have successfully employed the same procedure for pitchblende and crude sulphates containing little or no silica. Dr. Lind emphasized that a method may be highly specific in its applicability to a given radioactive substance. For example, the ignition method is successful with carnotites, but a complete failure under the same conditions for crude sulphates, while the fusion method succeeded with pitchblende but failed with carnotite.

Mr. Warren F. Bleecker agreed that the measurement of radium is essentially an indirect method quite difficult to make and is little understood except by experts. What is needed is a method which is easily worked and reasonably accurate. The situation is rendered difficult by the fact that a method once successful is not applicable to all classes of ore without previous examination. The ratio between uranium and radium, only holds in whole rocks—not in works which have been in any wise treated, either mechanically or chemically. Mr. Bleecker exhibited samples of uranium carbide, made in the electric furnace. The substance is of great interest as it is probably the grandparent of radium. Uranium carbide has remarkable properties, not yet fully understood.

Mr. W. R. Mott asked Mr. Bleecker whether he had any trouble from poisoning since uranium was one of the most poisonous materials we can get within the body.

This remark started a lively controversy. Mr. Mott based his claim on the statements of French scientists. Mr. Bleecker combated most seriously any notion there might be as to the poisonous effect of uranium, on the basis of his experience of working with uranium ores and uranium salts on a large scale for several years. Of course, there is dust and that is bad, but there are no poisonous effects.

The result of the discussion was the appointment of a committee, consisting of Messrs. W. F. Bleecker, W. R. Mott, and A. R. Ledoux, to get at the facts as to the poisonous effects ascribed to uranium and vanadium.

#### Silicidized Carbon-Silfrax

The first paper of the Friday afternoon session was presented by Mr. F. J. TONE, of the Carborundum Company, Niagara Falls, N. Y., on "Silicidized Carbon-Silfrax."

When solid carbon is acted upon by vapors of silica or silicon there is formed a silicon carbide product of the same shape as the original carbon but differing from carborundum in essential characteristics. To distinguish this form of silicidized carbon commercially, it has been given the name "silfrax." The properties and characteristics of the product vary with the temperature of formation. If the carbon article is heated in the amorphous zone of a carborundum furnace the temperature range of this zone being 1550 to 1820 deg., the product is amorphous in appearance, showing no crystals

except under high magnification. It has a yellow color and a lusterless fracture. If the carbon is heated in the crystalline zone of the furnace, the temperature of this zone ranging from 1820 to 2220 deg., the material is of great density and plainly crystalline. Upon fracture it shows a steel black color and a metallic luster.

The depth of the silicidizing action is mainly a function of the time of reaction and the concentration of silicon vapor present in the furnace atmosphere. To obtain the best conversion a large excess of silicon vapor must be present and the mixture should contain silica largely in excess of the theoretical carborundum mixture. Under regular conditions with articles of pure carbon the maximum penetration is about  $\frac{1}{2}$  inch. Articles composed of a mixture of carborundum and carbon can be readily converted to a greater depth.

Chemical analysis of the two varieties made in the amorphous and crystalline zones show that both are silicon carbide and give no basis for regarding the products as new compounds of silicon and carbon. Microscopical examinations show in all cases the presence of the typical hexagonal crystals of silicon carbide.

#### ANALYSES OF SILFRAX

	I	II	III	IV	V
SiC .....	93.33	91.03	93.39	96.86	94.19
SiO <sub>2</sub> .....	1.14	4.63	.75	0.94	3.10
C free .....	1.71	1.16	2.42	0.00	0.48
Fe and Al .....	3.84	3.94	2.07	1.42	1.62

I. Silfrax silicidized in amorphous zone of carborundum furnace.

II. Silfrax silicidized on edge of crystalline zone of carborundum furnace.

III. Do.

IV. Silundum.

V. Do.

Analyses of the SiC residue show it in all cases to consist of silicon and carbon in exact atomic proportions for SiC, and there can be no doubt that silicidized carbon by whatever name it may be called is silicon carbide.

Mr. Tone's paper then gives a number of interesting micrographs showing sections of carbon rods heated in both the amorphous and crystalline zones of the silicidizing furnace.

When carbon articles are subjected to the action of silicon vapors and molten silicon for a sufficient period the carbon is silicidized in the same manner as articles placed in a carborundum furnace, but the resultant product is carborundum containing varying proportions of pure silicon. Carborundum and silicon appear to be mutually soluble in all proportions and the physical and electrical properties of the carborundum are altered by the presence of silicon. A carbon block subject to this action in a silicon furnace furnishes a very suitable subject for investigation. Starting from the interior, which is unconverted carbon, the following zones are found:

(1) A greenish yellow product (E) not of great toughness and readily crushed down to the constituent grains, which are of great hardness. It is a poor conductor of electricity. On treatment with HF and  $\text{HNO}_3$  a bright yellow residue is left, which is perfectly crystalline and contains no amorphous material. Even the smallest particles under high magnification are crystalline and practically colorless.

(2) A uniform dense gray product (F), having a non-crystalline appearance, very hard, tough and difficult to fracture. Treatment with HF and  $\text{HNO}_3$  leaves a yellow crystalline material identical in appearance and properties with product E.

(3) A coarsely crystalline product (G), silver gray in color, very hard but more readily fractured than product E. The residue from treatment with HF and  $\text{HNO}_3$  is mostly yellow, but contains some dark grains and is entirely crystalline.

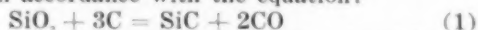
## CHEMICAL ANALYSIS OF PRODUCTS.

	E	F	G
Free Si .....	7.40	21.27	10.45
SiC residue .....	91.10	76.10	87.72
Fe .....	.25	1.40	.93
Al .....	.45	.57	.36
CaO .....	.80	.....	.....
	100.00	99.34	99.46
<i>Residue from HF and HNO<sub>3</sub>:</i>			
Si .....	69.40	.....	69.32
C .....	29.33	.....	29.29
Fe and Al .....	.....	.....	.10
	98.73	.....	98.71
	Apparent Density	S. G. of Residue	Resistivity Ohms cu. cm.
Product E .....	2.91	3.16	174.0
Product F .....	2.88	.....	1.8
Product G .....	3.10	3.16	9.3

Mr. Tone showed micrographs made from products E and F.

In discussing the difference between silfrax and ordinary carborundum, it is necessary to consider the reactions of the carborundum furnace. The reaction of silica and carbon is one which under varying conditions may be made to give a variety of products. Silicon carbide, silicon, silicon monoxide, siloxicon, graphite and modifications or mixtures of these may all be produced by variations in the mixture proportions of silica and carbon, temperature, pressure, rate of energy expended and other factors. In the carborundum furnace, carborundum is initially formed by the reaction of silica vapors on carbon beginning at a temperature of 1550 deg. The first carborundum so formed is always associated with silica and may be regarded as a definite compound, as siloxicon, or as a mixture or solid solution of silica and silicon carbide. Whatever may be its composition when treated with HF and HNO<sub>3</sub> it is freed from silica and silicon, the residue being silicon carbide usually in the amorphous state.

At a higher range of temperature complete conversion occurs in accordance with the equation:



On this equation is generally based the chemistry of the carborundum furnace, but as a matter of fact another reaction plays the most important part in the formation of carborundum and is here offered as a theory to explain fully all the phenomena of the furnace. Equation (1) explains only the conversion of carbon particles into carborundum *in situ*, the crystals or aggregates so formed being no larger than the original carbon particles. It is impossible to explain the growth of large crystals or crystals appreciably larger than the original carbon particles, unless it be granted that both the carbon and silicon when combining to produce these crystals are in the form of vapor. The largest and most perfect crystals are found in cavities or spaces where carbon and silicon in some form of gas or vapor have commingled and combined to form the solid crystals. Such form of carbon, however, cannot be vaporized carbon because it is well known that, at the temperature and vapor pressure of the carborundum furnace, carbon has no appreciable vapor tension. This is further proven by the fact that the effect of high temperature alone is to decompose carborundum, the silicon being vaporized and the carbon being left in a skeleton of the exact form of the original carborundum crystal.

If the vapor tension of carbon were appreciable these graphite pseudomorphs would not retain the perfect shapes of the carborundum crystals so generally observed. The theory is untenable, therefore, that carbon vapor and silicon vapor unite to form the large crystal growths.

To explain fully all the phenomena of the furnace the following reaction is necessary, the reaction being reversible:  $2\text{CO} + 3\text{Si} = 2\text{SiC} + \text{SiO}_2$  (2)

Carbon monoxide and vapors of silicon and silica are known to be present throughout the furnace atmosphere, and equilibrium relationships and the direction of the reaction in equation (2) depend on the temperature, pressure and the concentration of the reacting substances. The direct reaction is the low temperature reaction and is exothermic. It occurs throughout the crystalline zone, and on it is based the building up of the large crystals from the small crystals formed by equation (1). The reverse reaction occurs in the hottest part of the furnace and next to the core, and explains the phenomenon of the local disappearance of carborundum. This is observed in the rounded formation of the crystals next to the core, which have lost their sharp outline on account of being washed by the silica vapors. It is further observed in the smooth channels and blow holes cut through masses of crystals by the blowing out of the furnace gases. That carborundum can be decomposed or oxidized by silica is well known and is one of the methods of producing silicon.

Reaction (2) further explains the phenomenon of the recrystallization of carborundum first discovered by FitzGerald. Recrystallization can only occur in an atmosphere of CO, SiO<sub>2</sub> and Si. It is impossible to recrystallize carborundum in a pure atmosphere of CO by the action of heat alone.

Applying these considerations to silfrax it will be seen that it differs fundamentally from ordinary carborundum in its mode of production. It is produced mainly in accordance with equation (1), that is from the action of silicon vapors on carbon *in situ*, and not from gaseous carbon compounds. The crystals composing silfrax, therefore, are very small and closely aggregated. The development of large carborundum crystals requires free space for the circulation of gases. The largest and most perfect crystals in the carborundum furnace are produced in cavities resulting from the settling of the charge and these cavities are located at a point on the temperature gradient representing approximately the equilibrium temperature for equation (2). In producing silfrax the density of the carbon article is such that when the initial coating is formed the pores are almost completely filled with SiC, making the further circulation of gases very slow and difficult. Reaction (2) which is vapor reaction cannot occur to any extent and the crystals remain small and closely compacted. Silfrax is a crystalline aggregate while ordinary carborundum is a crystal or crystal aggregate.

To this is due the superior toughness and mechanical strength of silfrax.

The commercial applications of silfrax are as refractory materials, electrical heating elements and chemical ware. It has all the chemical and heat resisting properties of carborundum and in addition great density and toughness. Heretofore the articles produced have been of small size. Pyrometer tubes are now made 24 inches in length, and by special furnace construction it will be possible to make much larger sized articles for special refractory vessels and chemical apparatus. It has not yet been determined whether the material can be produced of sufficient density to be used as acid evaporating vessels, for which its very low coefficient of expansion and high thermal conductivity specially adapt it.

In the discussion which followed Dr. C. B. Thwing asked as to the suitability of silfrax for pyrometer tubes, as they should be superior to porcelain tubes, being more refractory and better heat conductors. He asked as to their permeability for gases. Dr. Richards asked whether silicon might vaporize which would attack the couple.

Mr. Horace W. Gillett replied that he had used silfrax tubes for a pyrometer for molten brass. The silfrax tubes may be plunged into the brass without danger of cracking. But at the temperature of yellow brass the tubes are not sufficiently gas-tight to allow a satisfactory use of the pyrometer as yet. There is needed an impervious inner coating for the tubes.

The further discussion centered chiefly around Mr. Tone's new theory of the formation of carborundum and especially its fundamental assumption that carbon has no appreciable vapor tension at the furnace temperature.

Mr. F. A. J. FitzGerald did not think that this has been proven or that it is generally admitted. He described a number of interesting experiments he had made on reactions between carbon tubes with silica or silicon, inside or outside, and from them he drew the conclusion that in explaining the phenomena in a carborundum furnace it is better to work on the hypothesis that we have appreciable vapor pressures not only of silica and silicon, but of carbon and silicon carbide. In any case before that hypothesis ceases to be useful, we need more experimental evidence than has so far been disclosed.

Prof. Jos. W. Richards referred to a method for calculating approximately the vapor pressure of carbon. He finds that at 1730 deg. C. there will be as large a vapor tension of carbon as there is of zinc in the sherardizing furnace. Since in the latter case zinc is plated out commercially, there is good reason for supposing that the tension of carbon vapor can play a very appreciable part in the reaction of the carborundum furnace.

Mr. F. A. Lidbury asked whether in the paper absolute conclusions had not been drawn in cases which admit of several interpretations.

Mr. W. R. Mott thought that at the temperatures in question the vapor pressure of carbon must be extremely small, because otherwise there could be no carbon-filament incandescent lamp.

Dr. W. C. Moore suggested that the graphite tube used in one of FitzGerald's experiments might have absorbed oxygen which might have been a disturbing factor in the results.

Mr. Tone stated that according to a calculation of Sir William Crookes carbon has zero vapor tension at 2700 deg. C. Very important experimental evidence is to be found in the graphite pseudomorphs obtained in the decomposition of carborundum by heat, the silicon being vaporized and the carbon being left in a skeleton of the exact form of the original carborundum crystal. They retain not only their crystalline outline, but the markings, workings, and spirals that often occur on the faces of these crystals. Mr. Tone thought that Mr. FitzGerald's experiments were not carried out in a way so as to exclude completely oxygen.

Mr. Alfred H. Cowles referred to some early experiments made by him.

#### Electrolytic Insulation of Aluminium Wire

A paper on this subject by C. E. SKINNER and L. W. CHUBB, of the Westinghouse Company, was read by Mr. Skinner.

Any gain in the efficiency of electric conducting material must be obtained by increasing the conductivity or decreasing the thickness of the insulation. The authors have found that it is possible to produce an insulating coating on the surface of aluminium wire which is so extremely thin that on many of the smaller sizes of wires it is possible to get a higher space efficiency, so far as the conducting material is concerned, in a coil with aluminium than with copper, even when the thinnest possible insulation is applied to the copper.

The skin or thin layer of natural oxide which is so objectionable in the soldering of aluminium is a non-conductor of high dielectric strength and the authors have developed a method of strengthening the coating by means of an electrolytic action which produces a coating of many times the dielectric strength of the coatings which has been obtained by former methods.

The various arrangements of apparatus which were devised in the development of the process are described in the paper. In the last one developed the wire passes straight through five tanks, of which the first and last contain hot water for washing and the middle three electrolyte. Solutions of borax, ammonium borate and sodium silicate are suitable electrolytes, the last being the best of the three.

The speed of treating wire varied from 40 to 150 feet per minute for the different sizes of wire used and the consumption of energy was from 0.15 to 0.80 watt hours per square inch of surface treated.

The insulation formed by the above is a thin film of alumina which is smooth and iridescent or abrasive and white. The smooth films form with a greater expenditure of energy and in inferior electrolytes. The white film formed in sodium silicate at about 425 volts is rather smooth to the touch, but so abrasive that it cuts and grinds the hand while coil winding. In some cases this treated wire running through the hand of the winder has cut through the skin and into the flesh before discovery.

The dielectric strength is far superior to the oxide coat formed by the former methods, for instead of standing a maximum of 0.5 volt two wires electrolytically treated and twisted tightly together without abrasion will stand from 200 to 500 volts.

The thickness of the film is apparently variable. Tests of change in diameter of wire before and after treating and tests of reduction in metal section by resistance measurements before and after treating show the coating to be from 0.0001 to 0.0004 inch (0.00025 to 0.001 cm.) thick.

On account of the thinness of the film it is quite flexible and does not open or appreciably weaken by sharp bends and kinks in the wire. Soft wire can be stretched 30 per cent of its length without apparently injuring the insulation. Two wires at a potential difference of 250 volts can be crossed and pressed together at the intersection until the wires are dented to such an extent that the intersection is no thicker than a single wire. If there is no relative motion between the surfaces in contact the insulation will not break down, but the slightest movement of one of the wires will cause a grinding between the surfaces which will at once cause a short circuit.

The insulating coating is fireproof and has sufficient strength mechanically to support the wire in small coils when the metal is above the melting point. Small coils run with the wire molten will fall to pieces if the current is suddenly stopped, but if the current is gradually lowered the metal will solidify and remain intact.

Electrolytically insulated aluminium wire is suitable for many classes of work requiring wires of relatively small size where the insulation requirements are not excessive and particularly where temperature requirements are severe. The very small sizes, No. 30 B & S Gauge and smaller, cannot be satisfactorily used on account of the difficulty in drawing the wire and in subsequent handling. In the very large sizes there is no advantage in the use of aluminium wire where the space is restricted. This wire has been found particularly advantageous for use in coils which require light weight and which are subject to relatively high temperatures, provided the insulation requirements on the individual wires are not excessive. The weight of an aluminium

wire coil is from 40 to 50 per cent of that of the equivalent copper coil. The thermal capacities of the two types of coils are practically the same and the temperature coefficients are equal. The heat dissipation through the aluminium coil is found to be slightly better than the equivalent copper coil.

While this new wire has limitations, it has a decided sphere of usefulness, which will probably be greatly extended, particularly in the event of the ratio between the base prices of aluminium to copper being decreased.

The paper was discussed by Mr. W. R. Mott and Mr. H. M. Hall, who had used such a process on square aluminium wire. In order to get satisfactory results at the edges he had to draw the edges rather blunt; it was still square wire, but the edges were appreciably rounded. Mr. Skinner replied that it is a fundamental principle in electrical work not to use wire with sharp square edges.

### Electropercussive Welding

A paper on this subject by C. E. SKINNER and L. W. CHUBB, of the Westinghouse Company, was presented by Mr. Chubb.

In the development of the process of electrolytically insulating aluminium wire (described in the preceding abstract) it was found that the making of joints in the wire itself was a serious problem. It was solved by developing the process of electropercussive welding. Two wires are welded together by causing a condenser discharge to pass between the ends of the wires in the moment when they are pressed together by mechanical force.

Fig. 5 shows a portable tool of the gravitational type

set to attach a copper lead wire to a coil of aluminium wire. The welding circuit (Fig. 6) consists of a direct-current line, or a generator  $G$  which charges an electrolytic condenser  $C$  through a high resistance  $R$ . Adjustment of the voltage of the charged condenser is obtained by field control of the generator or by varying the resistors  $R$  and  $R'$ . The wires  $WW$  to be welded are secured in the wire grips of



FIG. 5—APPARATUS FOR ELECTROPERCUSSIVE WELDING

the welding tool which are connected to the terminals of the condenser through an inductance  $L$  of from 2 to 10 turns of cable. A spring switch  $S$  with carbon contacts, normally held closed is connected across the jaws of the welder so that their potential difference will be zero while the wires are being put in or the finished product is being removed. The welder is connected to the auxiliary apparatus by means of long flexible cables which allow welding within a radius of about 50 feet without moving the con-

denser and without any other heavy apparatus.

The process of welding is as follows: The wires are secured in the wire grips and the ends cut off as short as possible with a suitable pair of cutters. The switch  $S$  is then opened which charges the condenser to the proper voltage, a catch is then released which lets the sliding member fall and bring the ends of the two wires into percussive engagement. At the instant of contact, the short circuit current of the condenser builds up to such a value that the ends of the wire are melted by the explosive discharge and instantly forged together by the blow of the falling mass. The weld is then complete and after being removed from the machine will be found to have the strength of the original wire.

The generation of the heat is so localized, so sudden and so intense, that there is no time for unequal heat

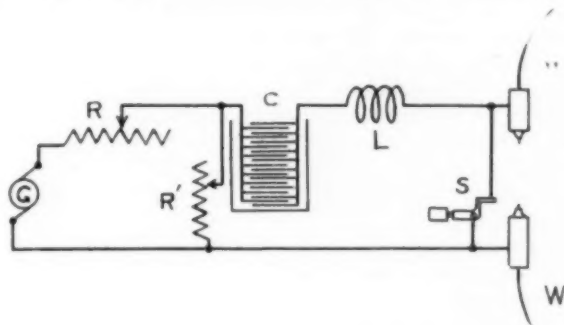


FIG. 6—ELECTROPERCUSSIVE WELDING

duction through the shanks of the wire and the ends will be melted and even vaporized whether the melting point is high or low. For this reason metals of different kinds can be welded together independent of their electrical resistance, melting point or heat conductance. Any combination of metals which has ever been tried will weld together, but the joints will not be permanent with such combinations as aluminium and tin, or lead and iron.

Electrically the weld is complete in 0.0012 second and although 23 kilowatts are being dissipated between the ends of the wire at a certain instant, the total energy used at the weld is about 0.00000123 kilowatt-hour or enough to light an ordinary 50-watt, 16-candle-power lamp for 0.09 second.

Many of the alloys of most metals are very hard and brittle. As an example, there are alloys near both ends of the copper-aluminium series which are unworkable, and yet electro-percussive welds between these two metals are so ductile that they may be worked in a die, forged, or rolled into thin foil. Any alloy formed at the weld must range from 100 per cent copper on one side to 100 per cent aluminium on the other; but possibly the brittle combinations are so thin that the joint as a whole is flexible and ductile. This joint between aluminium and copper is of great importance, as copper lead wires, which solder and connect easily, can readily be attached to aluminium coils. At first it was feared that a diffusion of the two metals in service would finally result in a brittle joint, but tests show that after four years the joints are practically as strong and ductile as when first made. Similar ductility has been noted in almost every combination of metals when first welded, but diffusion, disintegration and loss of ductility eventually result in such welds as silver to tin, or aluminium to tin.

Metals which are either hardened or softened with heating and sudden cooling can be welded together without appreciable change in the physical properties of the material. Tempered spring steel welded, reduced to uniform diameter, and tested has shown equal or greater

strength at and near the weld without any noticeable change in temper. Metals such as hard drawn copper, silver, aluminium, etc., which soften with heat can be welded together without causing any local annealing, and these metals and steel when soft can be welded together without detrimental local hardening.

This type of weld offers a very convenient specimen for the study of the diffusion of different metals at different temperatures and under various other conditions. Micrographs were given showing copper-platinum and copper-silver respectively. Both of these welds show a sharp dividing line at 1000 diameters. While the apparatus up to this time has been made only for the welding of wires, 0.072-inch diameter and smaller, the application to larger sizes is merely a question of the design of suitable apparatus.

### Electroplating

A paper by Prof. W. LASH MILLER, of Toronto University, dealt with "the formation of a badly conducting film on copper anodes in copper cyanide solution."

While preparing some experiments for the laboratory of the Toronto Branch of the American Electroplaters' Society, a current of about one ampere was sent through a copper cyanide bath (No. 3, below) using strips of copper 9 cm. x 3 cm. as electrodes, the 110-volt direct-current lighting circuit as a source of current, and a 32-candlepower carbon filament lamp as resistance in the circuit. The lamp, bright at first, within a minute's time burned dim, the evolution of hydrogen at the cathode fell off, and a voltmeter set over the cell showed a potential difference of 45 volts. On examination, the anode was found to be coated with a smooth yellow-green adherent deposit; and a few simple trials soon showed that the resistance of this film was the cause of the drop in current.

The formation of such a deposit evidently sets an upper limit to the current density at the anode that can be used efficiently with any given bath; a number of solutions recommended in the literature, which had been made up for another purpose, were tested from this point of view.

It was soon found, as expected, that the current density of which a noticeable film is formed depends on the shape and position of the anode and on the amount of circulation in the electrolyte; the simple apparatus shown in Fig. 7 was then constructed, and the various electrolytes were compared under the conditions obtaining in it.

In the figure, *A* is the anode, a cylinder of copper rod 2 cm. in diameter, *C* is the cathode, a hollow cylinder of sheet copper 2 mm. thick, 4 cm. internal diameter, slit down one side so that the height of the liquid could be read on a paper scale *S* pasted on the outside of the glass container *G*. Anode and cathode were held in position by means of two corks, of which the lower, *L*, was provided with a socket to catch the end of the anode and with notches around its edge to let the solution flow out evenly when the tap was opened. The zero mark of the scale was level with the upper side of the lower cork, its graduations ran from 1 to 10, and gave the area of submerged anode in tenths of a square decimeter; division 10 was 2 or 3 centimeters below the upper cork *U*.

To ensure that the liquid would run out of the cell at the same rate in different experiments, a glass nozzle was attached by rubber below the tap, and the latter was always either closed or wide open; with the nozzle used it took the solutions 60 seconds to fall from division

10 to division 1 on the scale, the volume comprised between these two marks being 197 cc.

Before each measurement, anode and cathode were cleaned by nitric acid, washed under the tap, and placed in the container; 250 cc. of an electrolyte was poured in through the funnel, the tap was opened, and as the surface passed division 10, the current (about one ampere) was switched on and its amount recorded. As the level fell, a voltmeter wired across the cell was read; at first the voltage was low, then suddenly began to rise, often with a well marked "jump," whereupon the circuit was broken, the cap closed and the level recorded; hence the current density when the sudden rise in voltage began was calculated. If the tap were left open, and the current on, the voltage rose rapidly until the needle reached the end of the scale.

Tests were made for various solutions and the results given in a table in the paper. Sulphate and carbonate solutions with different amounts of potassium cyanide, potassium and sodium carbonate, and ammonium hydroxide were tested. As a general rule not only cyanide, but ammonia or any other substances that hold the copper in solution, can be added to the bath to permit the use of a high anodic current density.

### Electrodeposition of Lead and Tin

Prof. FRANK C. MATHERS, of Indiana University, presented a paper on the electrodeposition of lead from lead acetate solutions.

Lead fluosilicate and lead perchlorate baths are the only ones that have been used successfully in lead plating. The great disadvantage or objection to them is that they must be made by special apparatus and by troublesome methods. The actual electroplating with either of them is very easy.

The deposits of lead which were obtained by the electrolysis of lead acetate baths containing ammonium perchlorate and peptone were much better than had been obtained previously from any lead salt of a weak acid. The cathodes were smooth during the first part of the deposition, but as the thickness of the deposit increased the cathodes became more and more rough. All of these deposits were brittle.

As these baths lacked something, the author has now tried various additions agents and has obtained smooth, finely crystalline deposits, much superior to those obtained with peptone as addition agent.

For each liter (1.056 quarts) of bath there should be used 100 gms. lead acetate, 40 gms. ammonium perchlorate, 25 to 50 cc. of glacial acetic acid and addition substance and an addition agent for which five different prescriptions are given. The best is this:

Treat 12.5 gm. of aloes with 500 cc. of warm water and shake until the soluble material has dissolved. Let stand until the insoluble tar or gum settles and adheres to the sides of the vessel.

Dissolve the insoluble tar or gum obtained from the extraction of 12.5 gm. of aloes with water, in the glacial acetic acid. Add this solution to the bath and electrolyze without filtering. No better addition agent than this was found.

A current density of 0.4 amp. per sq. dm. (3.6 amp. per sq. ft.) must be used for thick deposits. For thin deposits in plating 0.8 amp. per sq. dm. may be used. With the higher current density, ammonium acetate cannot be used in place of the ammonium perchlorate.

The current efficiencies at the anode and at the cathode are near 100 per cent. The excellent corrosion of the anodes is proved by the fact that the copper wires attached to the anodes in the solution were not dissolved. The specific gravity of the deposited lead was 11.27.

More of the addition substance and more acetic acid must be added to the bath during the course of the electrolysis.



FIG. 7—TEST CELL

Prof. FRANK C. MATHERS then presented a second paper, written by himself jointly with BARRETT W. COCKRUM, on "electrodeposition of lead from lead lactate and lead formate solutions."

This paper gives the details of experiments on the conditions under which a smooth, thick, firm, crystalline but rather brittle deposit of lead can be obtained from lead lactate and lead formate baths.

The baths that gave the best deposits contained 4 per cent of lead as lactate or 2 per cent of lead formate, 1 to 5 per cent of lactic or formic acid, 4 per cent of ammonium perchlorate and 0.25 per cent of Barbadoes aloes.

This mixture was warmed and then filtered in order to remove the insoluble gum which was in the aloes.

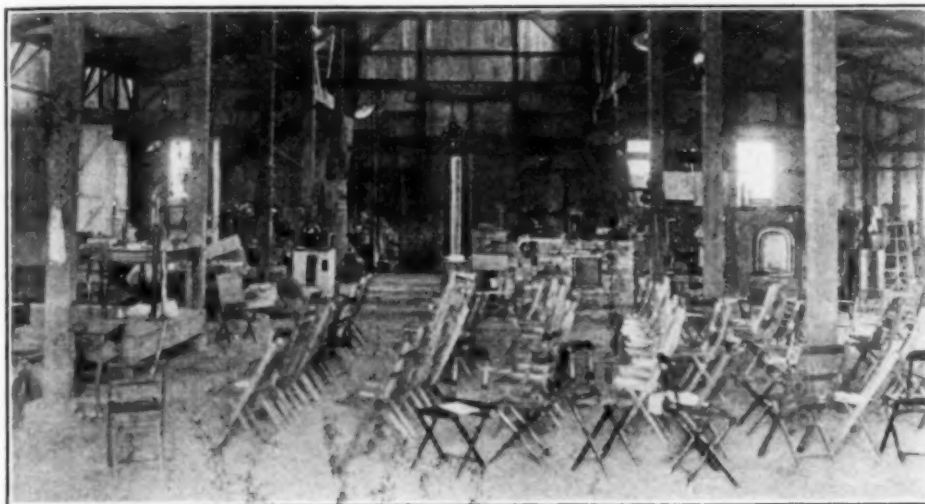


FIG. 8—ARRANGEMENT OF FITZGERALD LABORATORIES FOR SYMPOSIUM ON PRACTICAL ELECTROCHEMISTRY

A current density of 0.4 amp. per sq. dm. (3.6 amp. per sq. ft.) was found to be best; with higher current densities the deposit became rougher.

Thick deposits were obtained without difficulty. The specific gravity of this electrodeposited lead was 11.25 and 11.28 for the lactate and formate baths respectively.

Other addition agents were tried in the place of the Barbadoes aloes, but of these peptone was the only one of any marked value.

It was found that sodium naphthalene sulfonate could be used in the place of ammonium perchlorate. Other salts of strong acids did not give as good results as the perchlorate.

The only disadvantages in the use of baths containing lead salts of weak acids are:

- (a) A low current density must be used.
- (b) The deposits are brittle as a result of the large amount of addition substances that must be used.

Prof. FRANK C. MATHERS finally presented a paper by himself and BARRETT W. COCKRUM on "electrodeposition of tin from tin salts of mineral acids." A very extended research was made, but a method giving an entirely satisfactory deposit has not yet been framed. New addition agents are to be tried.

Professor Mathers illustrated the presentation of his papers by various interesting samples of deposits obtained under different conditions.

Messrs. W. Lash Miller, S. S. Sadtler, Francis C. Frary, Jos. W. Richards and G. A. Roush participated in the discussion. The latter pointed out that the density of the lead deposited by Mather is lower than that of cast lead. This is the reverse of the case of copper, electrolytic copper being always higher in density than cast copper.

Prof. J. W. Richards explained that cast copper contains gases which lower its specific gravity, while cast lead does not.

#### The Evaporator Problem in Electrochemical Plants

The Saturday morning session was opened by the presentation of a paper, by OTTO MANTIUS, on "the evaporator and the power problem in electrochemical plants." The paper is published in full elsewhere in this issue. (See p. 722.)

The paper was discussed at some length by Messrs. A. H. Hooker, L. V. Vorce and E. M. Sergeant. Mr. Vorce referred to a combination of double effect and single effect as a rather convenient form of evaporator operation which should deserve consideration.

The corrosion of the tubes was also the subject of various remarks. Mr. Hooker asked why in the vertical-tube type of evaporator the corrosion should always be in the upper parts of the tubes? If abrasion, why was it not greater in the first than in the second, since there is more salt in the former? Mr. Mantius replied that the speed increases enormously from the bottom to the top; for this reason the salt has a greater wearing action at the top of a tube than at the bottom. The top grows thinner. Also the speed is much higher in the last effect than in the first and second effect.

#### Symposium on the Practical Side of Electrochemical Investigation

After the presentation and discussion of Mr. Mantius' paper the whole of Saturday was devoted to a symposium on "the practical side of electrochemical investigation," consisting of "a number of informal



FIG. 9—ELECTRIC (GRANULAR CARBON RESISTOR) FURNACE FOR HEATING COFFEE AT LUNCHEON IN TRANSFORMER SUBSTATION

demonstrations of apparatus, methods, and materials used in electrochemical investigations or as electrochemical aids to chemical investigation."

This was an entirely novel undertaking and it should be stated at once that it was a full success and was thoroughly enjoyed by all who attended it.

The attendance was about 150 during the morning as well as the afternoon and the interest never flagged to the end.

The FitzGerald Laboratories where the symposium was held, are ideally suited for just such an undertaking, as they were founded and equipped not only for the development of electric-furnace and other processes (in which line the FitzGerald Laboratories have greatly distinguished themselves), but also for demonstration purposes. Excellent use was made of the power, furnace, and apparatus facilities available in this laboratory. Final success was assured by the esprit de corps of the Niagara Falls electrochemists who had stood together in the careful preparation of the symposium to make it a notable event. As a matter of fact, it went off without a hitch and proceeded exactly according to schedule.

As President Lidbury explained, one principal object of the symposium was to show how one can get along very well quite often in research work with simple home-made appliances instead of highly elaborate special apparatus.

The general procedure was that the man who would make a demonstration would first make a brief speech from the rostrum, explaining what he was going to show. Then the audience would pass over to the place where the demonstration was made, watch it, and finally return to their seats, when a general discussion would be started.

Mr. F. A. J. FitzGerald showed the heating of a carbon rod and the formation of a fused silica tube from sand placed around the carbon rod, with a convenient arrangement of four transformers which can be connected up in different ways for furnace regulation. The formation of carborundum crystals at the contact surface was observed. The matter was of interest in connection with his discussion of Mr. Tone's paper of the day before.

Mr. L. F. Saunders showed a resistance-furnace arrangement useful for melting-point determinations, the charge in the chamber being heated by radiation from a resistor at the top. This resistor is formed by a graphite plate sawed in such a way that incisions are made alternately from either side parallel to the end edges, so as to force the current to pass in a narrow zig-zag path through the plate and heat it. It is used directly on a 110-volt circuit. Such a resistor may be used for some seven or eight heats. Temperatures up to 2200 deg. C. can thus be produced.

Mr. Saunders then showed the behavior of an amorphous carbon tube in short-circuit between graphite blocks in a 50-volt circuit. When the tube heated up, the current increased to 1500 amp.

The construction of wire-wound tube and crucible laboratory furnaces with alundum as refractory was then shown, the method of winding being demonstrated by Mr. J. B. Glaze. Nichrome wire is used as resistor for temperatures up to 1000 deg. C.

Mr. FitzGerald showed a simple construction of a 50-volt 1200-amp arc furnace of the Stassano type with graphite electrodes and demonstrated in it the melting of lime. Vitrocarbon brick was used for the furnace roof.

This vitrocarbon brick is a new refractory brick of the National Carbon Co. As explained by Mr. A. T. Hinckley, this brick stands temperatures up to 2400 deg. C. in a reducing or neutral atmosphere. There is no shrinkage even at high temperatures. Vitrocarbon brick is a little cheaper than high-grade silicon carbide materials. Its heat conductivity is between that of silicon carbide brick and alundum brick. Its electric resistance is 1 ohm per inch cube, but decreases with increasing temperatures. It is an acid refractory.

Mr. Hinckley also showed a sample of a new "heat-insulating refractory brick," which has a heat conductivity 70 per cent of that of standard firebrick at 600 deg. C. and can be used up to 1400 deg. C. It cuts down the heat losses by 30 per cent.

The results of a Seger cone experiment were also shown, silicon brick cones and vitrocarbon brick cones being among the cones tested. The vitrocarbon brick had stood the test best.

Mr. Hinckley then demonstrated the method of measuring the resistance of joints of carbon electrodes screwed together, by the drop of potential method. The potential drop is measured over a length of continuous electrode and over an equal length containing a joint. A special paste of the National Carbon Company permits to reduce very much the power loss in the joint between two threaded electrodes

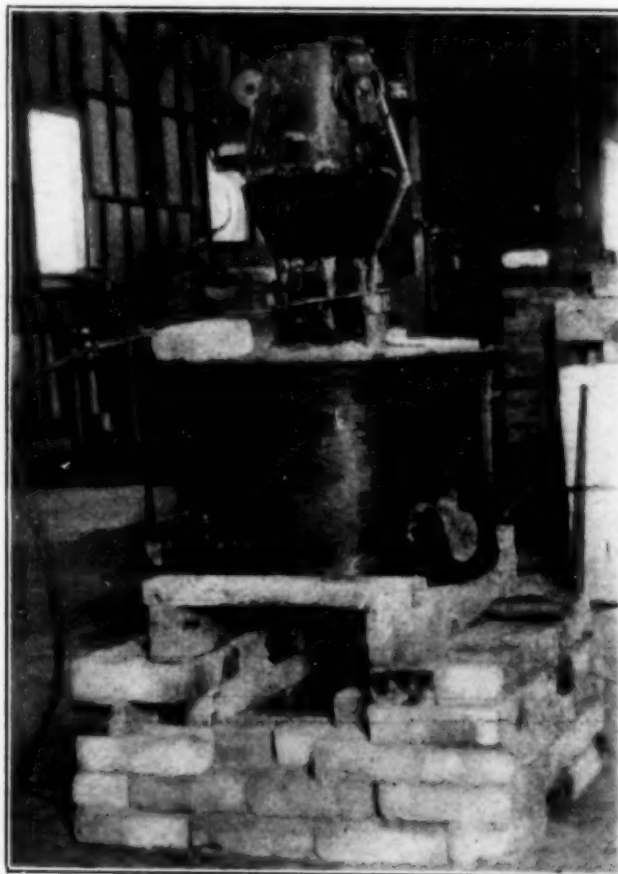


FIG. 10—ELECTRIC FURNACE FOR MELTING TIN DROSS

screwed together. The resistance of the joint is equivalent to 3 or 4 in. of carbon without joint. But the use of the special paste brings this figure down to 2½ or 2 in. Rex A tool steel is suitable for shaping, drilling, etc., carbon electrodes.

Mr. E. R. Cole demonstrated the great ease of machining Acheson graphite and the production of the most varied forms of graphite articles for special purposes, for instance, the production of a resistor tube by sawing a spiral curve into a graphite tube, further graphite terminals for mercury-arc rectifiers, etc.

Mr. Dantzisen showed a molybdenum-wire-wound alundum tube furnace of the General Electric Company for temperatures up to the melting point of alundum (about 1900 deg. C.). Oxidation of the wire is prevented by an atmosphere of hydrogen.

Dr. Carl Hering, of Philadelphia, Pa., showed a simple model of his pinch-effect furnace in which he demonstrated the melting of lead, the agitation produced by the "pinch effect" being clearly shown.

This was the last demonstration of the morning session.

Lunch was taken at the nearby Cliff Distributing Company's substation, where among other excellent things coffee prepared on a granular-carbon resistance furnace was greatly enjoyed. The highly original yet simple arrangement is shown in Fig. 9. For this as well as the photograph of the interior of the FitzGerald Laboratories (Fig. 8) we are obliged to Mr. J. Rattray Wilson, electric engineer of Niagara Falls and an amateur photographer of no mean ability.

A visit to a nearby linen factory followed.

In the afternoon session Dr. Hering's pinch effect furnace was first the subject of some discussion. As to the temperature difference between the resistor and the bath, Dr. J. W. Richards estimated that for a viscous metal it might be 100 deg.; for brass it would be hardly 20 deg. As Dr. Hering explained, this temperature difference depends on the viscosity of the metal and also on the pinch force. Barium chloride is not suitable for direct melting in a pinch-effect furnace, but it can be easily melted over a fused bath of lead. In a pinch-effect furnace in Philadelphia a good many tons of brass have been successfully melted.

In the development of the furnace the chief trouble experienced has been with the transformer. The energy of the motion in the furnace is represented by a counter electromotive force in the circuit. This is very favorable, as it allows the use of higher voltages at the furnace and a much easier design. But as it is not known exactly in advance, it may be that it comes out differently from what was expected, and the transformer has to be re-designed. A further transformer trouble is that if regulation is wanted, the power factor is poor.

Dr. Hering stated that there is absolutely no trouble with the resistor holes. They do not wear away. They are made of fused magnesite. The pinch-effect furnace can be used for reduction processes, but slag must not be permitted to get into the resistor tubes. Metal must always stay in the resistor tubes.

Mr. L. W. Chubb then demonstrated the electro-percussive method of welding aluminium wires together, as described in the abstract of his paper given above.

Mr. Raymond S. Wile, of Pittsburgh, Pa., demonstrated his electric furnace for melting tin dross. A view of the demonstration furnace is given in Fig. 10, while Fig. 11 is a diagrammatic sketch of its construction. The charge is fed into the furnace stack 2. The construction is shown for operation with two-phase or three-phase currents, when 4 are the upper electrodes and 6 the bottom electrode. 5 is the gear mechanism for adjusting the position of the top

electrode. The upper electrodes 4 do not come in contact with the tin dross being melted and their ends merely dip into the layer of slag. As slag, a layer of molten glass is used which also serves as resistor. The slag level is maintained constant by means of the overflow hole 7. The tin metal is tapped off through 8.

Most of the tin that evaporates is condensed in the column of charge coming down through the shaft. Any tin vapor which should not be condensed is recovered in a down comer. The loss of tin in the slag is only one-half per cent. The total loss by volatilization is  $1\frac{1}{2}$  to  $2\frac{1}{2}$  per cent, the actual furnace loss from  $\frac{3}{4}$  to 1 per cent of the tin charge.

In the discussion which followed the demonstration Mr. Wile stated that the specific energy consumption was from 600 to 900 kw-hours per ton of tin, depending on the size of the furnace and the consumption of the slag.

Further discussion centered on the starting of the furnace and regulation of temperature. The latter may be done by a transformer with different steps or by varying the thickness of the glass layer.

The furnace has been used not only for melting tin dross, but for melting glass, also brass and other alloys, and for the melting of the precipitates in cyanide plants.

Mr. P. E. Landolt of the Research Corporation demonstrated Dr. Cottrell's electrostatic method of precipitation of dust particles from fumes. Alternating current was transformed by a special synchronous commutator to rectified direct current at 40,000 volts. The demonstration was made successfully with zinc oxide and later with phosphorus fumes.

The latter experiment demonstrated the fact that the design of the apparatus and the voltage required depends on the rate of flow of gas and the amount of dust in unit volume.

The Cottrell process is now in successful use in cement works; for fumes from slime furnaces to recover gold and silver particles (copper refineries); for tin (stannic oxide); for zinc oxides; for lead fumes (Garfield); for lead sulphide from sintering machines (Tooele, Utah); for detarring illuminating gas; for precipitating sulphuric acid mist, flower dust, carborundum dust, borax dust, etc. In the near future the cleaning of iron blast furnace gases will be taken up.

Mr. Hinckley then demonstrated a method for determining the rate of oxidation of electrode materials used for different purposes. This may be determined either at constant temperature or at constant current or at constant voltage. Mr. Hinckley's determinations were made to constant temperature.

At 1000 deg. C. electrodes of equal porosity showed the following losses in grams per square centimeter per minute:

Graphitized electrodes.....	0.0050
Electrodes for steel furnace.....	0.0065
Fine-grained electrodes.....	0.0075

Mr. FitzGerald exhibited a tube furnace for melting point determinations in which the tube is embedded in granular carbon which is the resistor. This arrangement heats up less quickly than Mr. Saunders' arrangement shown in the morning, but has a longer life.

A thermoscope, using silver sulphide, was demonstrated by the FitzGerald Laboratories.

A threaded amorphous carbon electrode 20 in. by 84 in., of 1450 lb. weight, was exhibited by the National Carbon Company, the resistivity being 0.0017 ohms per inch cube.

After a hearty vote of thanks the meeting adjourned. The next meeting will be held in the spring of 1915 at Atlantic City, N. J.

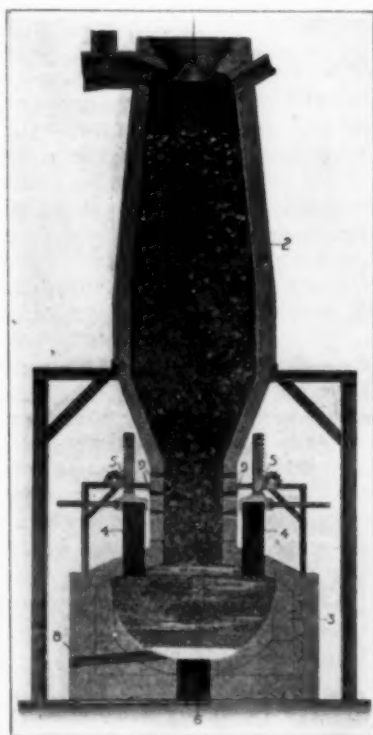


FIG. 11—TIN-DROSS ELECTRIC FURNACE

## The Hall Process of Desulphurization

In view of the commercial necessity of so operating smelting plants that noxious fumes of sulphur and other elements shall not contaminate the atmosphere, metallurgical experiments along this line have been important and interesting. At the present time the elimination of sulphur dioxide is the most important problem, since other deleterious gases and solids have been pretty well controlled.

At a recent meeting of the New York Section of the Mining & Metallurgical Society of America, Mr. H. F. WIERUM gave an account of what has been done with the Hall process, which aims to eliminate sulphur from sulphide ores and mattes without allowing sulphur dioxide to escape, and to recover the sulphur thus eliminated. The following excerpt is made from Mr. Wierum's address.

William A. Hall, the inventor of this process, tested his first ideas at a little place near Paris, called Levallois. He used a small brick-lined circular furnace, 18 in. or so in diameter, with a removable tile top, into which he introduced pyrites and which he heated by a very low-grade producer-gas carrying but 130 B. t. u. per cubic foot. The results obtained in this furnace were important only as an impetus to further investigations. No matter how many pounds of pyrites were treated, or how many cubic feet of gas were used, the tests resulted in a fairly complete desulphurization of the pyrites without yielding any detectable sulphur dioxide; the fumes from the discharge pipe of this furnace apparently consisted of white or yellowish-white sulphur vapor. Steam in small but unmeasured quantities was introduced with the gas through jets placed between the gas burners on the furnace.

These experiments were repeated in a similar furnace, in London, and later in Brooklyn, the gas in both cases being a city product of from 500 to 600 B. t. u. per cubic foot. The results were the same. It should be noted that in these preliminary experiments air was carefully excluded from the furnace, except such air as was blown into the burners themselves, in quantities just insufficient to burn completely the amount of gas introduced. Air was excluded in an efficient manner by maintaining a rather heavy back pressure in the furnace.

Of course, it has long been known that about one-half of the sulphur in  $\text{FeS}_2$  can be distilled from it by a mere application of heat, about 1300 deg. F., being required to start the distillation effectively. The remaining one-half, however, it has always been contended, cannot be dissociated from its combination with iron, or any other base, by simple heat. With these experiments before him, Mr. Hall drew up his first patent papers and attempted his first theory in the premises, and many a pencil was set busy trying to figure out possible chemical reactions that had apparently heretofore escaped the scientific world.

### Chemical Reactions

Now it is possible to write a reaction which will account for what the eye saw during those short tests, but whether such a reaction actually takes place *I am not prepared to say*, and I trust you will all feel perfectly free to form your own opinions as to the feasibility of such combinations as the following. Let us assume first that about one atom of sulphur has been distilled by heat alone from  $\text{FeS}_2$ , leaving a sub-sulphide of iron, which can be roughly designated as  $\text{FeS}$ . Now comes the first chemical reaction, whereby six molecules of  $\text{FeS}$  added to six molecules of  $\text{H}_2\text{O}$  at a suitable temperature are supposed to yield six molecules of  $\text{FeO}$  and six of  $\text{H}_2\text{S}$ . Doubts probably arise at once

in your minds as to the ability of any heat obtainable in a roasting furnace to decompose water in this manner. Nevertheless, here was this little furnace—with an air supply insufficient even to burn completely the gaseous fuel used—turning  $\text{FeS}_2$  into  $\text{FeO}$ , and having only the oxygen of *water* available as a stable equivalent for the sulphur in combination with iron. Red-hot iron decomposes water; why not red-hot  $\text{FeS}$ , or  $\text{Fe}_2\text{S}_3$ , or carbon, or red-hot *anything* that we do not know positively will *not* do it? Such were the questions we had to ask ourselves. So we go bravely on, and accuse the little furnace of decomposing enough water to satisfy the second reaction of the cycle:  $6\text{FeO} + 30 = 3\text{Fe}_2\text{O}_3$ . Following this comes the third chemical process, which I think is quite feasible under suitable conditions, provided the two foregoing reactions can be brought about:  $3\text{Fe}_2\text{O}_3 + 6\text{H}_2\text{S}$  (if formed)  $+ 50 = 2\text{Fe}_2\text{O}_3 + 6\text{H}_2\text{O} + 6\text{S}$  (free).

It seems fruitless, however, to discuss whether or not any such cycle of reactions actually occurs. I simply wish at this point to leave in your minds one fact, that in the little furnace described above,  $\text{FeS}_2$ , carrying some 48 per cent of sulphur, *was* freed from its sulphur, down to about 5 per cent, by a treatment with producer gas at a temperature of about 800 deg. C., introduced with insufficient air to burn this producer gas completely, and with some steam present, while maintaining such a strong back pressure that no suction whatever existed in the furnace, and no outside air could possibly have been drawn in.

The next step was the construction of a slightly larger furnace, mechanically rabbled, but of the same general design as the little pots just described. The only information gained by this increase in size and efficiency was to obtain a record as to how long the ore was under treatment, and very accurate and continuous data as to the amount of  $\text{SO}_2$  in the fumes. The result of official tests conducted by two of our most respected and experienced chemists and metallurgists indicated that  $\text{SO}_2$  was always below 0.1 per cent; that sulphur in the calcines was 3 per cent or under, and that the weight of ore treated per square foot of hearth area per 24 hours was approximately the same as in the regular MacDougal furnace.

Another point was tested in this second furnace. Some chemically pure sulphide of iron was bought, answering the formula of  $\text{FeS}$ . This contained no feeble atom of sulphur, nor unstable atom, or whatever you wish to call it, and yet this material was decomposed under exactly the same conditions as the pyrites, with practically identical results. In our later trials, this experience with monosulphide of iron, and also with some matte—which roughly answers the formula of monosulphide of iron—has always puzzled me and still does so.

### Commercial Experiments

When the tests had reached this point, I was called upon to carry out certain experiments that had been arranged by the gentlemen controlling the rights to this process, at a large smelter in California which had been closed down for some time. As you see, I had rather meagre data for the equipment of a unit to handle 25 or 30 tons of ore a day when the largest scale upon which the process had been tried so far had been about 25 or 30 pounds a day. I was unfortunately much pressed for time, under existing conditions, and had to attempt the impossible in getting a gas plant built, a furnace equipped, and tests completed within three months. It was found necessary to extend the time to be devoted to the tests; when this was arranged the gas plant was put in excellent shape, with washers and a fairly large gas holder, so that we we started up

again, about the first of the year, we had good clean gas to use. During this second construction period we equipped a second MacDougal furnace with oil burners. Strangely enough, the totally unsatisfactory tests which we had made with oil burners in Brooklyn led us to believe that raw oil was not a suitable fuel for our purpose, and therefore the equipment of a furnace with oil burners was undertaken simply as a side show, so to speak. This furnace later proved more valuable to us and to our knowledge of the process than did the gas-fired furnace.

About the first of January we started up the gas-fired furnace, but unfortunately were unable to keep it operating for 24 hours at a stretch during the whole month—not because of any difficulty with the plant or process, but because storm after storm interrupted the power communication of the plant. These interruptions occurred on an average of twice a day for the first two weeks of January, and nearly once a day for the last two weeks. Meantime, however, our oil-fired furnace was made ready, and we seized one occasion when the shut-down was more prolonged than usual, to put it into operation, having hastily provided steam power for most of our requirements. The early part of February, therefore, we started to run the oil-fired furnace. Although still subjected to many interruptions, we gradually eliminated these, and as the weather became kinder to us, after a week or so we began to feel that we knew what to do.

The ore which we had to treat was crushed to  $\frac{1}{2}$  in. and as it was not in the slightest degree friable, and was very dense,  $\frac{1}{2}$ -in. pieces were distinctly found to be too big. Therefore, a system of screen analysis was adopted on the calcines, and while our sulphur elimination from the material which passed the 10-mesh screen seemed to improve from day to day, nevertheless we found it extremely difficult to roast the ore down to the 5 per cent point which we aimed at under the conditions which we first imposed upon the furnace.

Careful analyses were made of the atmosphere existing on every hearth of this 18-ft. MacDougal furnace, and in the flue leading from it. For the first two weeks we devoted ourselves to tests in an atmosphere containing 1 per cent or less of free oxygen and rather generous percentage of CO; in other words, a highly reducing atmosphere throughout. Under these conditions we failed to get a better calcination than to about 11 or 12 per cent sulphur in the 10-mesh material. The larger pieces of ore, as they came from the furnace, were barely singed, and contained about 26 per cent sulphur, the original ore having averaged roughly 40 per cent. In all this period, hardly a trace of SO<sub>2</sub> existed in our escaping gases.

Time was again pressing and I found it impossible to try all the variations which I would have liked to try under these completely reducing conditions in the furnace. I therefore began slowly to allow a little oxidation to occur on the lower two hearths of the furnace, and while so doing we finally hit upon a set of conditions which seemed economically very important to the industry and to the problem of fume destruction. Let me state briefly what our best results were, maintained constantly for several days, and you will be able to judge whether or not we have reason to hope for important commercial developments in this process.

### Experimental Results

For about a week we fed at the rate of 24 tons in twenty-four hours. During this period the sulphur remaining in the 10-mesh calcines averaged  $5\frac{1}{2}$  per cent. The sulphur remaining in the total sample, of  $\frac{1}{2}$ -in. material, coarse and fine together, averaged about 8.8

per cent. Oil consumption was 22 gal. per ton of ore, the oil being a very cheap material carrying 25 per cent of asphalt and of about 23 deg. Bé. gravity. The SO<sub>2</sub> in the fumes escaping from the furnace for the entire period was a trifle over 0.3 per cent. Labor required is practically the same as for ordinary MacDougal roasting, and, of course, the more furnaces and the larger tonnage treated, the lower the labor cost per ton, inasmuch as it takes just as many men to tend and feed one furnace as four. Please note that although the figures just given you are the averages of hundreds of samples of gas and calcines, the entire period showed improvement toward the end, and gave us an opportunity to study what changes in the furnace itself would conduce to still more favorable results. Our best results, maintained for twenty-four or forty-eight hours, towards the end of this period, may be stated briefly thus: Oil consumption 16 gal. to 17 gal. per ton of ore; 10-mesh calcines, 5.3 per cent sulphur (although for two or three days the calcines ran between 2.8 and 3.6 per cent sulphur); SO<sub>2</sub> frequently as low as 0.06 per cent, so low, in fact, that we got tired of titrating to an end point in a very weak iodine solution.

I trust you will all bear in mind that these tests were made in an existing furnace in which all mechanical arrangements, such as speed, angle of rabble blades, depth of the bed of ore, and length of time in the furnace, had all been fixed for conventional pyrites roasting operation, whence it is not surprising that some of these conditions demanded amendment to give the best results for quite a different operation. Such amendments, I am sorry to say, were beyond our possibilities in the short time at our disposal, and our metallurgical common sense must therefore come to our help in predetermining roughly what effect certain changes will have. I think that with 10-mesh ore, and with arrangements for more frequent rabbling, and for keeping the ore in certain portions of the furnace a greater length of time than the present conventional practice provides, we can maintain without difficulty the following results. In an 18-ft. MacDougal furnace I believe we can treat 40 tons of 10-mesh ore daily with 500 gal. of oil, roasting it down to 5 per cent of sulphur, and controlling the SO<sub>2</sub> fumes so that they shall never exceed 0.3 per cent, and probably average 0.15 per cent or less. You understand that these figures have not been attained, but that I am giving them simply as my opinion as to what can be attained in time.

Now for a word or two about the chemical reactions. In the upper portion of the furnace about one-half of the sulphur is distilled by heat alone. The very lowest portion of the furnace, say one-third of the hearth area, is devoted to the oxidation of iron, copper and remaining sulphur, by a free admission of air. In the middle third of the furnace a strongly reducing atmosphere and rather high temperature, say 1500 deg. F., are maintained, and it is in this central portion of the furnace that the SO<sub>2</sub> formed below is broken up and reduced to elemental sulphur. It is an undeniable fact that some H<sub>2</sub>S is formed in the upper regions, and it is equally undeniable that H<sub>2</sub>S will react upon SO<sub>2</sub> under certain conditions, forming water and sulphur, but I have not been able to prove that the H<sub>2</sub>S—SO<sub>2</sub> reaction is the controlling feature in the reduction of SO<sub>2</sub>. When a too heavily reducing atmosphere is permitted in the presence of liberated elemental sulphur and steam, certain undetermined organic sulphides are formed which seriously interfere with the production of sulphur. There seem to be two ways of preventing this interference: first, avoiding too great an excess of fuel; second, a quick drop in the atmosphere at the point where these excess oil vapors and free sulphur

exist. Naturally, the former is the more economical way, but both have proved feasible.

#### Methods of Sulphur Recovery

We provided a Feld washing machine to clean the elemental sulphur from the gases, and for the first two or three hours after a free discharge of sulphur had been secured from the furnace, it looked as though this machine would take care of the sulphur most effectively; but, if my memory serves, four or five hours' creamy emulsion that came from the washer was led into tanks which had filter bottoms, the filtrate from which was beautifully clear and free from sulphur. Presently a disturbance appeared in the draft of the furnace, and investigation proved it to be caused by a complete clogging of all the gas passages in the washer. Fortunately we had provided facilities for by-passing the gases around the washer, and allowing them to escape from the stack into the air. This we did, and upon opening the washer found it completely clogged with yellow and gray sulphur, so sticky and plastic that neither a stream of water under high pressure nor a jet of steam would remove it from the interior surfaces.

Those who are familiar with the construction of a Feld washer will appreciate how impossible it was to clean the inaccessible spaces between the lead cones when once stuck up with this plastic mixture. After this first experience, we were able to use the washer for only an hour or so at a time, and then very ineffectively. Most of the time our gases, which consisted of a thick, heavy, yellow cloud of sulphur, were discharged through a fan to the stack and thence out into the atmosphere. Innocuous, it is true, but tantalizingly uneconomical.

To the small furnace in Brooklyn, we had previously attached a treater of the Cottrell precipitation type, and found that this electrolytic discharge was completely efficient in knocking down the sulphur. Unfortunately, business arrangements could not be made in the time at our disposal to install a Cottrell precipitation plant in connection with our MacDougal trials in California, so that until very recently I have been unable to say positively how well the liberated sulphur can be recovered. Our experience indicates that the current completely eliminated all solid sulphur from the gases, and I and most of my associates are reasonably sure that this method will prove both economical and efficient; it goes without saying that much experimentation will be required before satisfactory plant details can be worked out.

While looking into certain matters in Hungary about two months ago, I happened upon a Government sulphur factory which had been in operation for many years at a little place in Transylvania called Zalatna. I was interested to see with what facility the elemental sulphur was washed out of the gases in simple and inexpensive wooden towers containing many baffle boards over which a saturated solution of chloride of lime was flowing. The consumption of chloride of lime was almost nil; the emulsion coming from the foot of the towers was led into a series of tanks where the sulphur settled out quite completely without any filtering, and the clarified chloride of lime solution was again pumped to the top of the towers.

Naturally this suggestion seems a cheap way of solving our problem; I had three towers all half built in London, with the object of duplicating the performance which I witnessed in Hungary, when the war broke out and all business was stopped. Arrangements had about been perfected whereby I was to erect a plant in the northern part of Norway, similar to the one with which I experimented in California, but the war has also put

a complete stop to that, so that our Hall process has had ill luck thus far.

In the discussion following Mr. Wierum's address, he gave the following information.

"The upper portion of the furnace is under a nearly continuous back pressure, that is, the upper two hearths. The third hearth has no pressure. The fourth, fifth and sixth hearths have a slight suction, increasing, of course, at the bottom. This suction amounts to about 4 mm of water. On the hearths where there is a suction we can use any of the ordinary types of oil burners, and rely upon an aspirating effect to draw in enough air to burn the oil; but on the upper hearths, where there is a back pressure, you cannot burn oil in any of the conventional burners. I got my idea of a burner for that condition from Mr. Peabody, who has invented a burner which is used in the United States navy. This burner relies upon the pressure of the oil to atomize it; the oil at 40 to 60 lb. pressure is led through a very tortuous passage, and is finally discharged through a very small hole. This little jet is in the middle of a 4-in. pipe, through which comes the supply of air for combustion, being delivered from a fan at a pressure of about 4 in., a very small pressure. The burner is very cleverly arranged so that the direction of the air is inward and the direction of the sprayed oil is outward, so that the two counteract one another and produce a distinctly local ignition of the oil. So far as I know, this is the only burner that will maintain any desired temperature against a back pressure, and in an atmosphere containing no oxygen."

"The net result is that we have every reason to believe that it should be worth anybody's while to go ahead and finish these tests, at any reasonable cost, if he is interested in destroying sulphur fumes.

"I have always contended that it is a mistake to apply this process to any undertaking which requires close reckoning to figure out a profit. But at such operations as those in the Ural Mountains, or in Norway, or at Coram, at all of which places they have fairly cheap fuel and sulphur going to waste, with complaints about  $\text{SO}_2$ , there is no question in my mind that the salvage in sulphur would give you your roasting absolutely free, and eliminate the nuisance. But until we know that a profit can be made, and exactly how all details finally work out, I would not like to recommend anybody's installing it, for instance, in treating low-grade pyrites where the sulphur must be paid for in the first place.

"The cost of unpurified sulphur, with oil at 2.7 cents per gallon, figured out roughly at \$4.75 per short ton; to that must be added about \$3.50 for refining, because I do not believe that this sulphur is pure enough to sell to acid works."

#### Chemical Resources of California

BY SAMUEL H. DOLBEAR

A good deal has been said and written in the last few weeks in answer to the question, "What is the American manufacturer to do now that his supply of European commodities has been cut off?" Unless this question can be solved quickly, many of our industries, some of which have already suffered, will be badly crippled.

In reading what has been offered by various writers in the technical journals, it has appeared to me that the importance of some of our own natural chemical resources has not been fully appreciated. In fact, mention of them, has in some cases been entirely omitted. I find, for example, the suggestion that some substitute will need be found for magnesite and that potash may be entirely eliminated for the present from fertilizing mixes.

Having made a rather careful study of the chemical mineral deposits of California, I take the liberty of offering a few facts concerning the more important of these in the hope that it may assist in some measure in the solution of the case before us. The United States Geological Survey has published much information of value to chemical manufacturers and users, and these publications may be obtained in most cases for the asking.



FIG. 1—MAGNESITE MINE AND CALCINING PLANT, FRESNO COUNTY, CALIFORNIA

*Magnesite.*—This material occurs abundantly in California and several deposits have been equipped with calcination plants; two or three are now producing and another is expected to resume operations within a few



FIG. 2—CHROMIC IRON DEPOSIT, FRESNO COUNTY, CALIFORNIA

days. Prices have advanced sufficiently in this commodity to enable the producers to ship to the Atlantic seaboard since the European conflict arose, and with a market once created, it is believed that California mag-

nesite may be handled profitably under normal conditions via the Panama Canal.

*Quicksilver.*—Importations of quicksilver vary remarkably as in 1906 only 84 lb. were brought into the United States, while in 1911 there was imported nearly 472,000 lb. according to the figures of the United States Geological Survey. California has many producing mines, the total production of which to date has been about 2,160,000 flasks of 75 lb. each. Of late years exports have dropped off rapidly from 13,534 flasks in 1905 to 310 flasks in 1910. It is apparent then that our own production finds a market at home and that we are dependent upon European producers for only about 25 per cent of our consumption.

The high prices recently prevailing have brought about much activity in this direction and it is not likely that the mines of California, Nevada, and Texas will experience any difficulty in supplying the demand.

*Chrome Ore.*—Chrome ore has been produced in California to the extent of about 40,000 tons. The largest



FIG. 3—PLANT OF CALIFORNIA TRONA COMPANY, SEARLES LAKE, CAL.

production occurred prior to 1895, the decrease having been due to several causes, principal of which was the competition from New Caledonian and other deposits. Of late years the American production, which has come almost entirely from California, has been but a few hundred tons per year. With the stimulus of necessity, higher prices and lower freight rates through the canal, there is every reason to believe that activity in this material will result.

*Manganese Ore.*—There are numerous deposits of manganese in California and it is also found in Nevada and other Western States. Two of the California deposits are of easy access and one is within a freight rate of about \$1 to seaboard. By exercising a little care in the mining and selection of this ore, a grade of 75 to 80 per cent  $MnO_2$  may be maintained. Varying amounts of manganese ore have been shipped from California in the past years, the total production amounting to about 13,000 tons. It is entirely possible from a point of cost for California to supply such manganese ore as is used in the West and Central West in the ceramic arts, manufacture of dry and Leblanc cells, etc., under normal conditions. All that seems necessary to insure such production is new blood and sufficient capital to handle the industry.

*Ferro-Manganese.*—The Noble Electric Steel Company, at Heroult, Cal., is now equipping two of its furnaces, preparatory to producing this alloy. Others are also investigating the field with a view to its manufacture.

*Pumice.*—The volcanic regions of California are very extensive and large quantities of pumice are found in the State. On account of its abundance, it has found

new fields, such as its use in concrete building construction. The resultant concrete is so much lighter than that in which crushed rock is used that a substantial saving in structural steel is effected. From the abrasive point of view, some of the California pumice is equal in quality to that of the Lapari Islands.

**Baryte.**—I do not know that the European war will result in any great shortage of this product as the American production is far in excess of its importations. Baryte is found in various parts of California and Nevada, and a series of experiments in the production of barium compounds has been carried on in a manufacturing plant near Oakland. It is stated that production on a considerable scale will be commenced shortly.

**Flint Pebbles.**—So far as I know, the entire Californian production of pebbles has been used heretofore within the State. Suitable shapes have been found and while the hardness is not quite that of the European variety, they have given very satisfactory service in cement mills. Most of them are a quartz rather than flint but are regarded as flint pebbles by the trade. What are undoubtedly large deposits have remained undeveloped. In a number of cases there are close to rail and readily accessible. I mention this subject as many of the American grinding plants depend on Belgium and other European countries for their pebbles.

**Mineral Colors.**—This is a rather indefinite term, and the deposits in California which may, for convenience, be classed as "mineral colors" include a great variety of minerals and a greater variety of colors. In Arizona and Nevada there are also occurrences of this character. Efforts have been made to operate only a few of such deposits, the ochres having found the largest market. A properly equipped plant, capable of receiving the crude ore and turning out a product satisfactory to the trade would, without question, greatly advance this industry.

**Alkalines.**—In this connection I desire to call attention principally to the potassium salts as the suggestion has been made that it would likely be necessary to eliminate potash from fertilizing preparations entirely for the present, with a mention of the possibility of obtaining some relief from the preparation of kelp and from alunite, feldspar, etc.

At Searles Lake, in San Bernardino County, California, the discovery of potash in the alkaline deposit previously assumed to be chiefly valuable for its sodium carbonate content has attracted widespread attention. The available potash has been estimated at 30,000,000 tons. The United States Geological Survey and the Bureau of Soils originally laying claim to its discovery, were quite enthusiastic in the announcement of its discovery, but since it has been shown that the discovery of the presence of this important salt was the result of private investigation and was known some eight months prior to the departmental investigation, much space has been devoted to the possibility of finding undiscovered resources and the suggestion that it may be recovered from igneous and other rocks in which it is known to occur in an insoluble state. A good description of this deposit may be found in the *Engineering and Mining Journal* of Feb. 1, 1913.\*

**Conclusion.**—The items I have mentioned in the foregoing are but a few of the products which may be brought to account directly or indirectly in the present unusual conditions. The production of some of the salts of these elements, as is the case with magnesium chloride, is receiving serious consideration at this time. This latter is a source of great concern among those who require it, prices having advanced on the Pacific Coast from \$22.50 per ton to \$60 per ton. Experiments are

being carried on along three different lines: (1) that of the direct manufacture of  $MgCl_2$  from magnesite, (2) that involving the use of dolomite, and (3) through fractional crystallization of the bitter brines from the salt works, which brines are known to carry as high as 17.8 per cent  $MgCl_2$  at 30 deg. Baumé. With the advent of local potash production, the manufacture of its chromium salts, as well as metallurgical chrome compounds may result.

With the development of the chemical industry in California, increased production from other of its mineral resources may be expected. If the war in Europe be long protracted, California may be expected to play a most important part in the solution of some of the problems now confronting the manufacturers of this country.

San Francisco, Cal.

## The Evaporator and the Power Problem in Electrochemical Plants\*

BY OTTO MANTIUS

The electrolysis of sodium or potassium chloride solutions will produce liquors which with very few exceptions cannot be used or marketed without further concentration. In most cases considerable quantities of water have to be removed, and it is generally acknowledged that the cost for fuel, labor, repairs, interest and depreciation to be charged to the evaporating equipment have considerable influence on the rentability of the whole plant.

During the last few months we have heard a great deal about the conditions under which reciprocating engines, steam turbines or water power can be used for the generation of electric current to best advantage. In this paper I shall present some of the factors and conditions which should be considered when laying out an electrochemical plant where an evaporating system has to work in connection with water power or steam plant.

I shall not attempt to discuss the efficiency of the great variety of cells which are in daily use for the manufacture of caustic liquors, as the figures given below can readily be changed and discounted for any particular system. I shall not go into the question whether water, gas or steam should be used to produce the electric current. I shall restrict myself entirely to the discussion of those features and conditions which have a bearing on the design of the evaporating equipment.

The installation of an evaporator would be a very simple matter if we had to deal with sugar juice, black liquor or packing-house tank water. A double or triple effect for small quantities and a quadruple effect for larger amounts of liquor could be bought, installed and operated at comparatively low first cost and running expenses. The problem of a caustic liquor evaporator is somewhat complicated by the incrustations of the tubes, the corrosive action of the liquor itself and the high boiling point of the more concentrated solution, which practically eliminates the use of a quadruple effect even for large quantities, restricts the operation of a triple effect to certain favorable conditions, and makes a double effect the most economical equipment for a plant of medium capacity.

Inasmuch as this statement is quite contrary to ordinary practice, I give on p. 723 the figures for steam consumption of various equipments, which will explain and prove my contention.

My calculation has been based on the following assumptions:

\*A paper read at the Niagara Falls meeting of the American Electrochemical Society on October 3, 1914.

\*"Searles Lake Potash Deposit," by C. E. Dolbear.

Capacity in 24 hours	20,000 lb. (9091 kg.) NaOH.
Power required	1500 electric horse-power.
Weak liquor	20,000 gal. (75,750 liters) with 120 grams NaOH and 100 grams NaCl per liter.
Heavy liquor	3440 gal. (13,200 liters) with 700 grams NaOH and 16 grams NaCl per liter.
Evaporation	16,560 gal. (62,650 liters) in 20 hours = 828 gal. (3135 liters) per hour.

The hourly steam consumption, including radiation loss, preheating of the weak liquor from 70° F. (21° C.) and evaporation of the wash water, will be as follows:

Single Effect	—7900 lb.: 6000 lb. direct steam, 1900 lb. exhaust from pumps (3590; 2727 and 863 kg.).
Double Effect	—5090 lb.: 3690 lb. direct steam, 1400 lb. exhaust from pumps (2312; 1676 and 636 kg.).
Triple Effect	—4600 lb.: 3400 lb. direct steam, 1200 lb. exhaust from pumps (2090; 1544 and 546 kg.).
Triple Effect and Single Effect	—4300 lb.: 3000 lb. direct steam 1300 lb. exhaust from pumps (1952; 1362 and 590 kg.).

Single effect and double effect are to be operated with steam at 7-lb. and 20-lb. gauge pressure (0.5 and 1.3 kg. per sq. cm.), triple effect at from 60 lb. to 70 lb. (4 to 4.7 kg. per sq. cm.) and the combination triple effect and single effect with steam at from 7 lb. to 20 lb. (0.5 to 1.3 kg. per sq. cm.). In the latter arrangement the triple effect concentrates the weak liquor to about 400 grams per liter, and the single effect finishes the process to 700 grams NaOH per liter. This arrangement will permit the use of low-pressure steam, and should always be used where larger quantities of liquor have to be handled.

The above figures show that the efficiency of the evaporator increases with the number of effects as usual, even if the difference is not as large as might be expected from general practice. The comparatively high steam consumption of the high pressure straight triple effect is due to the increased radiation losses and the large amount of wash waters to be handled and preheating to be done.

These conditions will change as soon as we use a part or all of the exhaust steam of engines or turbines for the evaporation of the caustic liquors.

Where the electricity for the cells has to be generated in a steam plant, either steam turbines or reciprocating engines may be used and the exhaust utilized in the evaporator. As the quantity of steam required for power purposes is about three times larger than the amount needed for the evaporator, the ordinary method of using all the engine exhaust at about 5 lb. (0.3 kg. per sq. cm.) pressure for the concentration of the caustic liquor can only be applied in very small plants by running the evaporator about 7 hours per day and operating the engine during the rest of the time in connection with the condenser attached to the evaporator.

In most cases it is necessary to run a multiple effect evaporator continuously and utilize only a part of the steam, which has entered the engine or turbine at high pressure and is withdrawn at from 20 lb. to 30 lb. (1.3 to 2.0 kg. per sq. cm.). I find that for this kind of work steam turbines are not quite as suitable as reciprocating compound engines, as in a steam turbine a large part of the work is done during the low pressure period. While actual tests on small compound engines show that 10 lb. (4.5 kg.) steam withdrawn from the receiver at 20 lb. (9.1 kg. per sq. cm.) pressure require only from 5 lb. to 6 lb. (2.25 to 2.75 kg.) extra steam at 125 lb. (8.3 kg. per sq. cm.) pressure, the guarantees given for large steam turbines ask for 8 lb. (3.6 kg.) extra steam at 150 lb. (10 kg. per sq. cm.) pressure added for 10 lb. (4.5 kg.) steam withdrawn at 20 lb. (1.3 kg. per sq. cm.) pressure.

To produce 20,000 lb. (9091 kg.) NaOH in 24 hours the steam plant should develop 1500 electric horse-power. A compound condensing Corliss engine will

use 15 lb. (6.8 kg.) steam per electric horsepower per hour and increase its steam consumption 1 lb. (0.45 kg.) for every 2 lb. 0.91 kg.) discharged from the receiver at 20 lb. (9.1 kg.) pressure or higher.

Assuming that 1 ton of coal furnishes 15,000 lb. (6820 kg.) of dry steam at a cost of \$3, i.e., 1000 lb. (454 kg.) of steam for \$0.20, the steam and coal consumption of engine and evaporator combined will then be as follows:

#### Single Effect.

Engine	1500 × 15 × 24 = 540,000 lb. (245,300 kg) steam
Evaporator	3000 × 20 = 60,000 lb. ( 27,270 kg) steam
Pumps	1900 × 20 = 38,000 lb. ( 17,270 kg) steam

638,000 lb. (289,840 kg) steam

Fuel cost per day = \$127.60; per 1000 lb. (454 kg) NaOH = \$6.38.

#### Double Effect.

Engine	1500 × 15 × 24 = 540,000 lb. (245,300 kg) steam
Evaporator	1845 × 20 = 36,900 lb. ( 16,760 kg) steam
Pumps	1400 × 20 = 28,000 lb. ( 13,330 kg) steam

604,900 lb. (275,390 kg) steam

Fuel cost per day = \$120.98; per 1000 lb. (454 kg) NaOH = \$6.05.

#### Triple Effect and Single Effect.

Engine	1500 × 15 × 24 = 540,000 lb. (245,300 kg) steam
Evaporator	1500 × 20 = 30,000 lb. ( 13,635 kg) steam
Pumps	1300 × 20 = 26,000 lb. ( 11,820 kg) steam

596,000 lb. (270,755 kg) steam

Fuel cost per day = \$119.20; per 1000 lb. (454 kg) NaOH = \$5.96.

A straight triple effect naturally cannot be operated on steam of 20 lb. (1.3 kg. per sq. cm.) pressure, and live steam has to be used altogether.

#### Triple Effect.

Engine	1500 × 15 × 24 = 540,000 lb. (245,300 kg) steam
Evaporator	3400 × 20 = 68,000 lb. ( 30,900 kg) steam
Pumps	1200 × 20 = 24,000 lb. ( 10,900 kg) steam

632,000 lb. (287,100 kg) steam

Fuel cost per day = \$126.40; per 1000 lb. (454 kg) NaOH = \$6.32.

In all cases evaporators and pumps work only 20 hours per day, while the cells are naturally operated during the full 24 hours.

These figures show that for a production of 3600 tons caustic per year the cost of fuel is about \$2,000 higher for a straight triple effect than for a double effect or combination triple and single effect. Besides, we must not forget that a high-pressure triple effect is considerably more expensive in first cost and repairs, and is sometimes difficult and even dangerous to operate. Wherever possible, evaporators for caustic liquors of high density should be operated under vacuum, as it will prevent loss of caustic and reduce the corrosive action of the liquor.

Quite a number of electrochemical plants obtain the necessary power at very low rates from central power plants, but have to install boilers to furnish steam for the evaporators. At first glance it would appear that a high-pressure triple effect might be the most economical equipment, but the following figures will prove that as far as cost of power is concerned a different arrangement is preferable. Let us assume that only \$22 is charged for 1 electric horse-power per year and that 1000 lb. (454 kg.) steam cost \$0.20 as before.

#### Straight Triple Effect.

Cost of energy .....  $\frac{1500 \times 22}{365} = \$90.40$

Evaporator and pumps .....  $4600 \times 20 = 92,000 \text{ lb.} = \frac{92,000}{365} = 252.05$

\$108.80

Therefore 1000 lb. (454 kg) NaOH = \$5.44.

We have seen before that a combination triple and single effect can be operated at low pressure and uses less steam than a straight triple effect. We can, therefore, first use the high-pressure steam in a special compound engine to furnish a certain amount of power at not any cost for fuel, and then utilize the exhaust for the evaporation of the liquor. Assuming that the engine will use 23 lb. (10.5 kg.) per hour per electric horsepower, and therefore produce 130 electric horsepower from the available 3000 lb. (1364

kg.), we have only to purchase 1370 electric horsepower, outside power, and the cost will be as follows:

Combination Triple and Single Effect.		
Energy .....	$1370 \times 22 =$	\$82.60
Engine and evaporator.....	$130 \times 23 \times 24 =$	14.40
Pumps .....	$1300 \times 20 =$	5.20
		\$102.20

1000 lb. (454 kg) NaOH = \$5.11.

This would mean a saving of over \$2,400 per year, less interest, depreciation and repairs of engine. Quite frequently it might not be desirable to install such an engine, but there will always be a number of pumps and small engines the exhaust of which should be used in the evaporating equipment.

We could even go a step further and install a 500-hp. compound condensing engine, use in the evaporator steam taken from the receiver and contract for only 1000 hp. to be taken from the central station. Considering the cost of extra labor, repairs and depreciation, we would not save much, but the engine could be arranged so as to take up the peak load, for which otherwise in most cases heavy penalties have to be paid, and the plant could be operated at two-thirds of its normal capacity by shutting down the engine without having to pay for more than the 1000 hp. Besides, the plant has not to be closed down entirely in case the central plant should not be able to furnish the current.

Similar conditions prevail in plants where gas engines or heavy oil engines are used to generate the current for the cells. A double effect or combination triple and single effect using exhaust steam from auxiliary engines and pumps will give the best results.

A type of engine used very little in this country is the Lentz patented superheated steam engine, which even in small units will produce current at surprisingly low cost. I was told last year during a visit to Germany that 1 electric horsepower hour can be produced by 10 lb. (4.5 kg.) of steam and less in a 300-kw. unit. This would make the Lentz engine the ideal motive power for small plants furnishing bleach liquor and caustic for paper mills.

The foregoing figures lead to the conclusion that a straight triple effect operated with high-pressure steam should never be used for the concentration of caustic liquors. The first cost is high, and the expenses for fuel, repairs and renewal are more than for any other arrangement. Besides, such a triple effect is considered by many people a general nuisance and source of trouble on account of the difficulties in keeping joints and valves tight.

As far as the cost of fuel per 1000 lb. (454 kg.) NaOH is concerned, there is not much difference between a single, double or combination triple and single effect, but low first cost and simplicity of operation should induce us to choose a single or double effect for small capacities up to 5 tons NaOH per day; for larger plants, and especially where the cost of coal is high, and large amounts of cooling water can be had at only considerable expense, a double effect or combination triple and single effect should be installed. The proper arrangement has to be determined for each plant, and no general rules can be given.

I wish to add a few words concerning the general design of the evaporating equipment:

1. For small single effects operating only 10 hours per day no reserve is needed, as all repairs can be done over night. The piping of multiple effects running continually should always be arranged so that any pan can be cut off entirely for repairs.

2. Steel, charcoal iron or nickel steel tubes should be used only up to 40° Bé., as the corrosive action of

caustic up to this density is very small, and any kind of tube will last a long time, unless the liquor contains a considerable amount of corrosive impurities.

3. For the concentration from 40° to 50° Bé. and higher, only special cast-iron tubes should be used, because cast iron is the only material that will withstand the action of the hot concentrated caustic liquor. In Germany almost all the caustic liquor above 40° Bé. is handled in cast-iron evaporators. The first cost of such an equipment is somewhat higher, but this difference is soon paid for by the saving in repairs and the increased efficiency of the plant, as there is no time lost in shutting down to replace worn-out tubes. Some of the largest manufacturers of caustic in this country prefer to use copper tubes almost exclusively, as copper will wear longer and more uniform than steel or charcoal iron. Besides, the scrap value of the discarded tubes is quite high. On the other hand, the first cost is considerable, and where large amounts of salt have to be handled the copper tube disappears quickly on account of the mechanical abrasion caused by the salt passing along the copper surface at high speed.

It was not my intention to consider all possible combinations between evaporator and the source of power, as this is not the time and the place to make such an exhaustive investigation. I only wished to point out the economic and practical disadvantage of a high-pressure straight triple effect when handling caustic liquor up to 50° Bé., and the good results that may be obtained from a compound or triplex condensing engine when working in connection with a double effect evaporator or a combination of low-pressure triple effect and single effect with a cast-iron heating surface.

Buffalo, N. Y.

## Electro-Chemistry and Metallurgy in Great Britain

(From Our Special Correspondent.)

### The Institute of Metals

The meeting of the Institute of Metals announced to be held at Portsmouth on the 10th and 11th of September did not take place on account of the war. But the papers which would have been read and discussed were formally presented at a meeting in London on the 10th and discussion was invited by correspondence in the Journal of the Institute.

### The Influence of Coke on Corrosion

In their second report to the corrosion committee of the Institute of Metals, Dr. G. H. Bengough and Mr. Jones gave out, as the result of their researches, that coke exerted no deleterious action when in contact with immersed Admiralty brass, and generally had rather a beneficial effect.

Mr. Arnold Philip, in a convincing paper, flatly contradicted the statements so made, which he regarded as an entirely erroneous departure from the generally accepted views on the theory of corrosion. The report in question stated, in effect, that coke in close contact with condenser tubes of Admiralty brass, whether in stagnant or running sea-water at ordinary temperatures, had no material influence on the amount of corrosion, either local or general, and did not cause dezincification, but in general had a slight retarding effect on the speed of corrosion.

The author asserted most positively that coke in contact with condenser tubes in sea-water caused an acceleration of corrosion which was a very real and important source of trouble, and this was a fact which

had been known for many years to all engineers who had to deal with corrosion, particularly in connection with condenser tubes, and had long ago attained the status of a truism. He had made many dozens of experiments with pieces of Admiralty brass condenser tubes to which fragments of coke were tied with cotton, and immersion in either stagnant or running ordinary sea-water at temperatures varying from atmospheric up to 50 deg. C., proved that in every case an acceleration of corrosion was caused by the coke, while an appearance of dezincification was produced in two days at ordinary temperatures.

#### Depositing Metallic Coatings by Spraying

A paper by Mr. R. K. Morcom described an effective method of uniformly depositing metallic coatings by spraying heated metal by means of high-pressure air or gases. The apparatus is the subject of British patent No. 2801 of 1912, and consists essentially of two concentric nozzles with a central carrier for a wire of the metal to be deposited.

The inner, or melting, jet focusses a flame of oxy-hydrogen or other gaseous fuel on the wire at a short distance from the nozzle, while the outer or spraying jet delivers air or other suitable gas at a pressure of 80 lb. per square inch, which carries away a stream of minute particles of the heated metal and deposits them on the object to be coated and also serves to keep the nozzles and object cool.

It is stated that the hand can be held in the jet without inconvenience and be coated with metal. The consumption of air is from 45 to 50 cu. ft. per minute, and the most economical rate of supply of gases for the melting jet is about 1.5 cu. ft. of hydrogen and 0.5 cu. ft. of oxygen, or about 0.8 cu. ft. of coal gas with 0.65 cu. ft. of oxygen per minute.

The manipulation of the apparatus can be varied to produce either porous or non-porous coatings, and, with certain metals, any deposit from pure metal to pure oxide. Fusible non-metallic substances can also be sprayed, and alloy deposits may be obtained from stranded wires.

#### The War and Engineering Trades

An order of considerable magnitude for the machinery and steel work for the construction of dock gates, caisson and swing bridges at the new extension of the Royal Albert Docks was, before war was in sight, placed in Germany by the Port of London Authority. The carrying out of the contract in that country being now out of question, it has now been given to Sir Wm. Arrol & Company, of Glasgow.

The trade of Sheffield has already undergone marked improvement, and continued expansion is practically certain to follow. The bayonet works are naturally very active; a valuable order for shoes and dies for Freemantle, which would in the ordinary course have gone to Germany, has been received, and fairly heavy contracts for steel work for Japan represent new business.

At Birmingham the small arms and ammunition factories are working day and night; good orders for locomotives and rolling stock have been transferred from German firms to British engineers, and a considerable share of the work has come to the district, while orders from the War Office for light constructional steel work, corrugated sheets, barbed wire, tubes and pumps are keeping many works very busy.

In the Tyne district firms doing Admiralty work are keeping their shops going continuously—day and night and Sundays—to cope with the demands for war material, and there is considerable difficulty in obtaining an adequate amount of skilled labor.

#### Market Prices September, 1914 Prices not official

	£.	s.	d.	£.	s.	d.
Aluminium ingots, ton lots				83	0	0
Alum lump, loose, per ton	5	5	0 to	5	10	0
Antimony, black sulphide powder, ton				25	0	0
Borax, British ref. crystal, cwt.		18	6 to		19	6
Copper sulphate, ton	17	10	0 to	18	10	0
Copper ore, 10% to 25% unit						
Caustic soda, 76%, cwt.		9	9 to		10	3
Ebonite rod, lb.					3	6
Hydrochloric acid, cwt.					2	10
India rubber, Para, fine, lb.					5	0
Mica in original cases, medium		3	0 to			
Petroleum, Russian spot, gal.					7	17 9/4
Quicksilver, Spanish, bottle					2	2 0
Sal ammoniac, cwt.	40	0	to	16		0
Sulphate of ammonia, ton						
Sulphur, recovered, ton					3	2 6
Shellac, cwt.					9	5 0
Platinum, oz., nominal						
Tin ore, 70%, ton						
Zinc sheets, scarce	42	10	0 to	45	0	0

The Metal Exchange remains closed.

**Tin.**—General depression was somewhat relieved towards the middle of the month by Continental demand through absence of German supplies, Standard being quoted about mid-month at £134 to £136 on minimum quantities.

**Copper.**—In copper the exchange remained closed. At the beginning of the month, owing to restricted selling consequent on this, copper changed hands as low as £52. Best selected was officially fixed at £57.10.0 to £58.10.0 (11th).

**Scotch Pig.**—Market very quiet. Settlement price 57/—.

**Haematite.**—Settlement 66/—.

**Cleveland.**—At mid-month 52/11, but has since declined considerably, being quoted later at 50/11½.

**Lead.**—The market is quiet. English lead is fairly steady at £19.15.0 to £20.0.0.

#### Recent Chemical and Metallurgical Patents

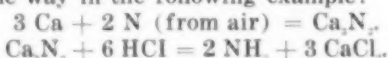
##### Fixation of Atmospheric Nitrogen

**A New Nitride Process.**—Among the various processes for the fixation of atmospheric nitrogen one particular class which has attracted considerable attention in recent years is characterized by, first, the production of a metallic nitride by reaction of the metal with atmospheric nitrogen; second, by production of ammonia from the nitride, and third, the regeneration of the metal, so that with respect to the metal the process is cyclic. Perhaps the first suggestion in this line was to use lithium (this journal, April, 1906, p. 122). The lithium nitride, formed by the reaction  $3\text{Li} + \text{N} = \text{Li}_3\text{N}$ , is treated with water, yielding ammonia and lithium hydroxide, and the latter is electrolyzed for the regeneration of metallic lithium. This was considered too complicated and expensive. One special process which has furthest advanced on this principle is the Serpek process in which aluminum nitride is produced from bauxite and nitrogen, followed by decomposition of the nitride by water or caustic soda solution, thereby liberating the nitrogen as ammonia and producing alkaline aluminate solution from which pure alumina can be obtained (this journal, Vol. X., p. 745, Vol. XI., pp. 137, 139, 281).

Two patents just granted to Prof. JOHN E. BUCHER of Brown University, Providence, R. I., describe a new process which in its general principle belongs to the class above described. Its distinctive feature is that the nitride is not decomposed by water or caustic soda solution, as above, but by a mineral acid, or by some other hydrogen compound such as the acid salts, ammonium salts, etc. In the patents examples are given for the following acids, acid salts, etc.:  $\text{HCl}$ ,  $\text{NaHCO}_3$ ,  $\text{NH}_4\text{Cl}$ ,  $\text{NH}_4\text{Br}$ ,  $\text{NH}_4\text{I}$ , etc. The advantage claimed by the inventor over the use of water or caustic soda solu-

tion for treatment of the nitride is stated as follows: "A characteristic property of nitrides of the metals and metalloids—lithium, magnesium, calcium, barium, strontium, aluminum, silicon, etc., and of boron nitrid—is their power to decompose water at the ordinary, or at more or less elevated temperatures, as the case may be, to form gaseous ammonia, and a hydroxide or oxide of the metal or metalloid. This method of producing ammonia is not economical because the oxide or hydroxide remaining has little value as such, and must be reduced to the metallic state before it can absorb nitrogen to reform the nitrid, and it is very much more difficult and expensive to reduce the oxides and hydroxides of the nitride forming metals than to reduce the haloids of said metals.

The principle of the Bucher process is shown in the most simple way in the following example:



"Electrolysis of the so produced chloride of calcium gives chlorine and calcium, and the former may be utilized as such, or may be used to form hydrochloric acid, while the calcium may be converted into calcium nitride to be reacted upon by hydrochloric acid. My process is hence adapted to any industry wherein hydrochloric acid is available or wherein it may be produced."

As adapted to the ammonia-soda industry, the process is described as follows: "Many attempts have been made to utilize the chlorine of common salt, used in the ammonia-soda process, for producing bi-carbonate and carbonate of soda. Solvay and Mond made many experiments with this end in view, but up to the present time none have proven economically successful. The common practice of to-day allows all of the undecomposed common salt, which amounts to about 30 per cent of the total quantity used, and much of the chlorine of the decomposed salt to go to waste, some of the chlorine combined with calcium being recovered and utilized as calcium chloride. My invention renders possible the saving and utilization of all of the undecomposed common salt, and substantially all of the chlorine of the salt which becomes decomposed, while furthermore resulting in an increase of approximately one-third of the quantity of ammonia present in the cycle.

"The manner of conducting my process in connection with the ammonia-soda industry is as follows: The mother liquor from the crude bi-carbonate of soda produced in the carbonating tower is evaporated to dryness in any suitable evaporator; and the free or volatile ammonia is collected by brine in the usual manner; a residue consisting essentially of a mixture of dry ammonium chloride and sodium chloride being obtained. This mixture is then heated to the subliming point of ammonium chloride, to wit, about 300° C., and the ammonium chloride is condensed to a solid sublimate leaving the sodium chloride behind in an especially pure condition, suitable for any use, such as table salt, or for strengthening the brine used in the ammonia-soda process; while all of the ammonia corresponding to the decomposed sodium chloride is thus recovered in the form of dry ammonium chloride. The ammonium chloride is then brought into contact with a nitride at the proper temperature, usually a dull red heat. Many nitrides are capable of reacting with ammonium chloride, in practically all cases with evolution of heat, producing ammonia or ammonium chloride and a chloride of the metallic base of the nitride. For example, calcium nitride reacts, in this connection, as follows:  $\text{Ca}_3\text{N}_2 + 6 \text{ NH}_4\text{Cl} = 8 \text{ NH}_3 + 3 \text{ CaCl}_2$ .

"The reaction in this case evolves sufficient heat to maintain itself after it has once been started, and if

moisture be excluded, which is preferable, the reaction takes place quantitatively and anhydrous ammonia and anhydrous calcium chloride are produced. The ammonia needs only to be cooled and compressed, either by the pressure produced in the generator, or by mechanical compression, to immediately liquefy it. The calcium chloride hereby produced is well suited to serve as an electrolyte in an electric furnace, and is preferably so used in the electrolytic step of the proc-

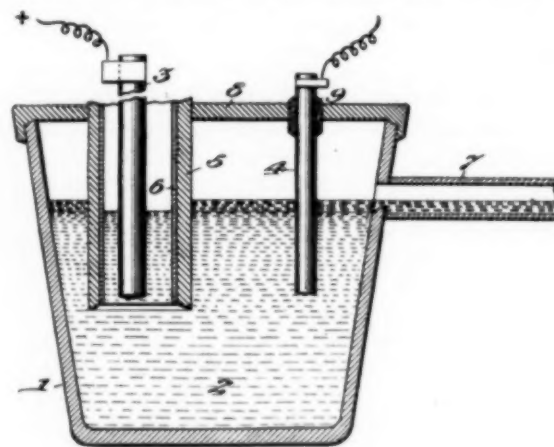


FIG. 1—ELECTROLYTIC FURNACE

ess leading to the re-formation of calcium nitride." Various reactions are also mentioned in which magnesium is the metal in the cyclic process instead of calcium.

The electrolytic process is carried out as follows: In Fig. 1, the iron pot 1 contains the fused salt 2, while 3 is the anode and 4 the cathode. Chlorine is set free at 3, collects within the tube 5 and is carried off. The metal (calcium, magnesium, sodium, etc) is set free at 4 and carried off through tube 7 and is then "introduced into the reaction tube 10, Fig. 2, which latter may be heated in any suitable manner, as by a number

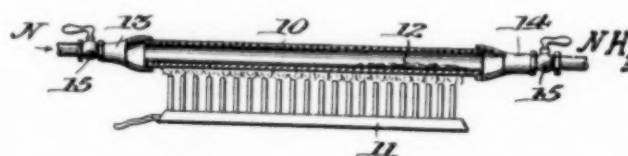


FIG. 2—REACTION TUBE FOR PRODUCTION OF NITRIDE

of Bunsen burners 11. The sodium 12, for example, in the retort or reaction tube is converted to a nitride by passing nitrogen or a suitable nitrogenous reagent, e.g., free nitrogen, through the tube, such reagent passing thereinto from a tube or pipe 13, and the unused portion of the same escaping via tube 14. Cocks or valves 15 may be provided in these last-mentioned pipes. The halogen, e.g., chlorine, escaping from pipe 5, is collected and may be combined with hydrogen, for example, to form hydrochloric acid; and when the nitride of magnesium, for instance, in tube 10, is reacted upon with said acid, which may be introduced into said tube in any suitable manner, as by injection \* \* \* ammonia formed may escape through tube 14, while the resulting reformed haloid salt will remain in the reaction tube, from which it may be afterward removed preparatory to again electrolyzing the same." (Patents 1,113,598 and 1,113,599, October 13, 1914.)

**Absorption of Nitrous Vapors in the Dry and with Heat by the Aid of Lime.**—A patent of ALPHONSE THEOPHILE SCHLOESING, Paris, France, applies to a

process by which a better heat-regeneration is obtained in the fixation of atmospheric nitrogen. Air is dried with sulphuric acid before entering the electric heating furnace (in which discharges are passed through the air) and leaving the same the air contains nitrous vapor. It then passes into a heat-exchanger, where part of its sensible heat is given off to the gases escaping from the absorber, freed from nitrous vapor. These re-heated gases can now be used to dry and dehydrate the lime used for the absorption of those nitrous gases in the absorber. The gases which gave off part of their heat are still further cooled down to about 300 or 400 deg. C. and enter now the absorber, where their nitrous content is retained. Leaving this absorber still hot enough, part of it may be used to concentrate the sulphuric acid for air-drying, whereas the other part is re-heated in the heat-exchanger as set forth above. No external heating is required throughout this process. (1,092,295, April 7, 1914.)

#### Metallurgical Furnaces.

**Melting Furnace.**—A combined reverberatory and stack furnace is described by GRENVILLE MELLEN, of East Orange, N. J. The flame passes over an inclined hearth and through an arch into the shaft, where it pre-heats the charge. The molten metal accumulates in a sump, where it is separated from any lumps by a refrac-

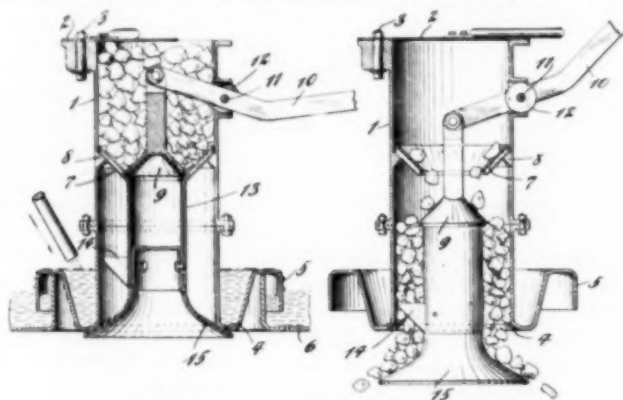


FIG. 3—HOPPER FOR GAS PRODUCER

tory shield. The product can be further treated in a refining chamber, which is protected from radiation by a cover. Finally it flows into a pot in front of the furnace. (1,092,938, April 14, 1914.)

**Hopper for Gas-Producers.**—To evenly distribute fuel in a producer, WM. A. JONES, of West New Brighton, Staten Island, N. Y., has devised the hopper shown in the two diagrams of Fig. 3. It consists of an upper loose ring 7, closed by the valve 9 extending cylindrically below and ending in a flared spreader-plate, fitting tightly to a seat 4, on account of the looseness of ring 7. Three guides for the bell are also provided. The distance with which the coal will fall from the producer-center will depend upon the height of its fall, the angularity of the spreader plate and finally also on the height above the coal surface. (1,090,857, March 24, 1914.)

**Reversing Valve.**—A reversing valve, in which the use of cooling water is almost avoided and the walls are brick-lined and cooled by air is patented by JEROME R. GEORGE, of Worcester, Mass. The valve itself is divided into sections, one of which is closed by a cover being lined and connecting two gas flues of the heating furnace. The open segmental section is for admission and regulation of air, its two connecting walls between the circular wall-ends and the skew-back, being curved. Air pockets are provided between lining and shell, to cool the former. Only skew-back and pan receive cooling water. (1,093,047, April 14, 1914.)

#### Electric Furnaces.

##### Electric Melting Furnace for Medium Temperatures.

—ERNESTO STASSANO, of Turin, Italy, and NAPOLEON PETINOT, of Niagara Falls, N. Y., have obtained a patent on an electric melting furnace for copper, alloys, etc., the furnace being of the radiation type. The furnace has already been described in our October issue, page 645. The main features are the eccentricity of the furnace shell and melting chamber, the axis of the latter being above the other. On account of this thicker refractory filling the bath is well protected against heat losses, whereas the highly heated but thinner roof allows a better cooling. A charging device, consisting of a turning-disk with a funnel, a hopper closed on top, permit charging without admitting air to the furnace. The electrodes are inclosed in a cylinder and held by a hollow water-cooled rod, sliding on guides and moved by means of hydraulic pressure. (1,093,494, April 14, 1914.)

##### Calcination of Granular Carbon and Production of Graphite.

—A continuous electric furnace for the production of granular graphite is patented by JOHN W. BROWN, of Lakewood, O. (National Carbon Company). The vertical and polygonal type contains an outer and an inner cylindrical wall, with a cover on top, through which the upper carbon electrode reaches into the furnace. The three lower horizontal electrodes pass through sleeves in the inner and outer walls and cannot with a cylindrical carbon channel, at the bottom of which a conveyor removes the granulated product. The charge, fed into the hopper, is carried upwards by a hoist between the two cylindrical walls and absorbs thereby heat from the hot product inside. The charge is tilted on top, passes the intense hot zone and falls into the carbon

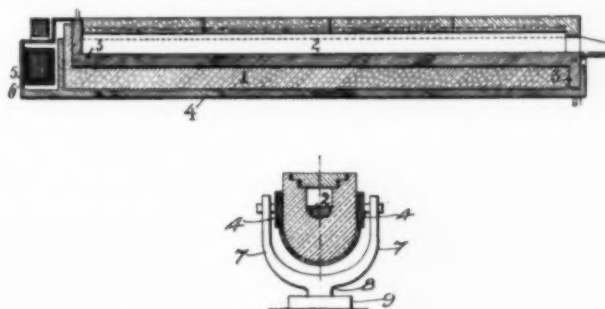


FIG. 4—INDUCTION FURNACE

channel where it gives heat off to the fresh charge. A vertical modification and two horizontal designs are further described. (1,093,382, April 14, 1914.)

**Electric Induction Furnace.**—ALOIS HELFENSTEIN, Vienna, Austria, uses the casing of a long-shaped furnace as conductor for the secondary current to the bath. This casing surrounds the furnace concentrically effecting thereby a natural cooling. Fig. 4 shows a vertical longitudinal section, a vertical cross-section, and a plan of the furnace. 1 indicates an extended furnace tube in which the metal 2 to be heated by the current is contained. At the ends of the tube water-cooled poles 3 are arranged, which transmit the induced secondary current on the one hand from the secondary winding 6, and on the other hand through the furnace-casing 4 to the metal bath 2. The primary winding of the transformer is shown at 5. (1,093,328, April 14, 1914.)

**Moving-Electrode Furnace.**—Instead of fixed elec-

trodes, HENRY H. BUCKMAN, Indianapolis, Ind., uses rotating electrodes to obtain a better and quicker distribution of heat in an electric furnace. Three electrodes are being carried by a support, fastened to a vertical rotating member. These arms and the member are water-cooled and the electrodes isolated from the support, one conductor leading direct to the middle electrode, while the other divides and supplies the two outer ones. All three electrodes rotate eccentrically with different distances from the center to cover as much surface as possible of the bath, the current passing through and from the middle to the two outer electrodes. The distance of these outer electrodes from the center electrode is kept equal. (1,092,764, April 7, 1914.)

**Electrode Construction.**—According to a patent of JOHN W. BROWN, of the National Carbon Company, electrodes can be built up of segments and keyed together by means of ribs and complimentary grooves, both being shunted to insure a wedging action of all the parts. The electrodes are best started with varying lengths, the ends of each being leveled to force them into better contact. The center may be made hollow. (1,091,559, March 31, 1914.)

### Iron and Steel

**Refining Pig Iron.**—Pig iron can be improved so as to be equal to cold blast-iron, according to a patent of VICTOR STOBIE, Sheffield, England. The liquid metal from the blast-furnace is treated in an electric-furnace under a refining-slag of about 60 per cent lime and 40 per cent silica and kept free from iron oxide by additional carbon or deoxidizer. The bath is stirred up by throwing limestone into it, the carbonic acid causing violent evolution. After this the bath is allowed to rest. Too much limestone would reduce silicon, manganese and phosphorus. (1,093,892, April 21, 1914.)

**Direct Production of Iron and Steel in a High-Pressure Furnace.**—CARL OTTO, Dresden, Germany, describes a somewhat complicated method of producing iron or steel in a furnace under pressure. Spongy iron is first produced by carbon monoxide in a clay vessel heated from the outside by producer-gas. At the bottom is a charge of pure iron or steel, on top of it is charcoal mixed with ore, and on top of this a fuel chamber is provided, containing inferior fuel with an electric resistance imbedded herein. The vessel with the charge is heated and the CO<sub>2</sub> from the reduction zone passes up and into the electrically heated fuel chamber. The CO so produced is used partly for burning and the other part takes the place of the CO<sub>2</sub> in the ore-chamber for further reduction. Gas-circulation is produced by a blower. A second electric resistance is provided at the base of the vessel to form and maintain a sump of mother metal, which bath under pressure also absorbs CO, so removing all remaining protoxides. (1,089,951, March 10, 1914.)

**Use of Peat in Production of Sponge-Iron.**—Objections to the use of peat as fuel in iron reduction reside in its tendency to disintegrate in the shaft furnace and its inability to sustain the burden of the charge. It is proposed, however, by PER ANDERSON, of Arvika, and ERIK EDSON ODELSTIERNA, of Stocksund, Sweden, to make use of this fuel in a metallizing or sponge-iron process, by thoroughly mixing the powdered peat with iron ore, charging the mixture in a receptacle and heating the latter externally by combustion of gas. The reduction thus takes place while the ore and metal are still in a solid state. (1,105,870, Aug. 4, 1914.)

### Gold and Silver

**Treatment of Anode Residue.**—Anode residues from the electrolysis of copper bullion contain gold, silver and some copper. The recovery of the copper and the

preparation of the precious metals for subsequent refining and separation, are objects of a process patented by Dr. EDWARD KELLER, of Perth Amboy, N. J. The anode residues are first filter-pressed and then treated with concentrated commercial sulphuric acid in just sufficient quantity to dissolve the copper present or render it soluble. After this treatment the copper can be dissolved in hot water, and the decopperized precious-metal residue refined for the formation of Doré bars. For residues from crude converter copper, the following mixture is made: 2000 lb. residue (41.2 per cent copper) and 2760 lb. sulphuric acid at 66° Baume, or 67 lb. of acid per unit (20 lb.) of copper. For residues from refined copper: 2000 lb. residue (15.1 per cent copper) and 460 lb. acid at 66° Baume, or 30.7 lb. acid per unit of copper. The mixture is heated at a temperature of about 450° F. and subsequently dissolved in hot water, whereby from 95 to 99 per cent of the copper is recovered in a neutral solution suitable for return to the electrolytic tanks. (1,110,493, Sept. 15, 1914.)

### Copper and Zinc

**Improvement in Bessemerizing Copper Matte.**—In the usual method of recovering copper from matte the latter is blown in a converter with the addition of silicious flux, with the result that there is first formed a slag of silica and iron which is skimmed, after which the blow continues to reduce white metal, or sulphide of copper, to the metal. The copper is subsequently treated in a reverberatory furnace, where a slag containing copper silicate is formed. An improvement in this procedure is claimed by Mr. JAMES B. HERRESHOFF, JR., of New York City, in a patent which he has assigned to the Nichols Copper Co. The invention contemplates the utilization of heat formerly wasted, and the more efficient retreatment of the reverberatory slag.

Using two basic converters, silicious material and matte are blown in the first one until a clean fusible slag is made containing part of the iron in the matte. This slag is removed and silicious material added in excess of the requirements of the remaining iron. The blow is continued until all the iron has been slagged and white metal produced. The slag and excess silica are now a viscous mass, from beneath which the white metal is poured and transferred to the second converter and blown to blister copper. A new charge of matte is then added to the viscous slag in the first converter and the process repeated. By this method the silicious material is heated by the bath or charge, and when brought into contact with the next charge of matte tends to raise its temperature instead of cooling it. Another advantage claimed is that cleaner slags are produced, because at no time is slag poured from a bath of copper. The reverberatory slag mentioned above can be used to advantage as silicious flux in the converting operation. (1,103,925, July 14.)

### Alloys

**An alloy of tungsten and nickel,** having the property of ductility, and from which the nickel can be completely removed without resort to fusion, is patented by Mr. HANS KREUSLER, of Wilmersdorf, near Berlin, Germany. The alloy and the method of making it are specially applicable to the production of metallic tungsten filaments for incandescent electric lamps. Alloys of 90 per cent tungsten and 10 per cent nickel prove to be of special utility. The nickel can be driven from finely drawn wires of such an alloy by subjecting them to heat in a highly rarefied atmosphere or in a vacuum, as by passing an electric current through them. The resulting tungsten wires can be used as lamp filaments. (1,110,303, Sept. 8.)

## The Electric Crane in the Electrolytic Copper Refinery

In several branches of the metallurgical industry the electric traveling crane has virtually become a part of the process and performs various functions aside from the transportation of materials. It would be difficult to conceive of an open-hearth steel works without the

that the lifting frame cannot possibly tilt and drop the electrodes, even if the load is unbalanced, while at the same time all tendency of the load to sway due to the travel motions is effectively resisted.

This crane has three independent motors for respectively the hoist, the cross travel of the trolley and the longitudinal travel of the entire crane along the runway. The operator's cage is supported from one of the

bridge girders and at the center of the span, and the speed and accuracy attained by an experienced operator are little short of amazing.

Prior to delivery in the tank house each group of thirty anode castings is assembled in racks on a transfer car, the anodes being correctly spaced with reference to the position of the hooks on the lifting frame.

Fig. 1 shows the operation of the crane while placing the anodes in the electrolytic tank.

Fig. 2 shows the crane with a lot of refined copper cathodes immediately after removal from the electrolytic tank.

The illustrations are from photographs made at the works of the United States Metals Refining Company at Chrome, N. J.

The cranes were built by the Shaw Electric Crane Company, one of the subsidiaries of Manning, Maxwell & Moore, Inc.



FIG. 1—PLACING THE ANODES IN THE ELECTROLYTIC TANK

several distinctive types of electric cranes that have been developed along with the mill practice, and somewhat analogous conditions prevail in modern plate glass works and particularly in the "casting-hall" where large crucibles of molten glass are withdrawn from the furnaces and poured by electric traveling cranes of special construction.

The crane shown in the accompanying illustrations is employed for the single purpose of handling the electrodes of electrolytic copper refining tanks. The lifting frame comprises two parallel I-beams from each of which depends a series of hooks which engage the supporting lugs on the electrodes. With the lifting frame lowered into position, a slight movement of the trolley or carriage along the bridge serves to engage the hooks and the entire anode or cathode content of the tank is then lifted in the one operation.

The distinctive feature of this crane is the rigid-bar hoist, the two vertical bars supporting the lifting frame and traveling in heavily braced guides as shown in the illustration. The principal advantage lies in the fact

The reported discovery of platinum in the Boss mine in the Goodsprings, or Yellow Pine, mining dis-



FIG. 2—CRANE WITH CATHODES AFTER REMOVAL FROM ELECTROLYTIC TANK

strict in Nevada, seems to be confirmed by the published assays of a reputable eastern firm. Palladium and gold also are said to occur with the platinum, giving an ore of unusual value.

## Calorizing

### Coating Metals with a Layer of Aluminium Alloy for Protection Against High Temperatures

H. B. C. Allison and L. A. Hawkins, of the Research Laboratory of the General Electric Company, Schenectady, N. Y., have published an interesting article on "Calorizing" in the October issue of the *General Electric Review*, from which the following notes are taken.

Mr. T. Van Aller discovered a process of heating metals in revolving drums with mixtures containing, among other things, finely ground aluminium, by which a surface alloy containing aluminium is produced (From this it would seem that the process, in its principle is similar to sherardizing. See our Vol. V, page 187, and VI, page 191.) In the case of copper, this alloy is of the nature of an aluminium bronze, but richer in aluminium than the ordinary alloy of that name and more resistant to heat, so that copper thus treated is protected up to the melting period of the alloy from the scaling which occurs when untreated copper is heated above 300 deg. C. The same general result was obtained in the case of iron and steel. Some use was made of this process, which was called "calorizing," for treating copper soldering irons and iron resistance wires for heating devices.

Modifications of the process, extending it to further applications, were made by Mr. E. G. Gilson, of the Schenectady Research Laboratory. Pieces which, because of their shape or size, are not adapted for tumbling, may be calorized by packing them in, or painting them with, a suitable mixture, and heating them. Thus, the size of the heater is the only limitation on the size of the piece that may be calorized. Wire or ribbon may be treated by a continuous process, by passing it through a heated pipe containing the proper calorizing mixture.

There appear to be many places where it is desirable to use iron vessels or apparatus at temperatures above red heat, and at such temperatures, ordinary iron rapidly oxidizes and scales away. After iron is calorized the effect of heating is slight. Instead of burning and the scale falling off, as in the case of untreated iron, practically no effect can be detected after a considerable time—certainly none which injures the surface.

Another application of this process is to iron wire or ribbon such as is used in electrical heating units. An untreated piece of this ribbon will burn out in four or five hours at the most, whereas tests upon calorized pieces have shown that the life is increased at least fifty fold, and in the best instances over one hundred fold. The results of tests made at Pittsfield indicate that a life of over 500 hours may be expected from calorized heating units run at a temperature of 800 deg. C.

Calorized seamless iron tubing is being used for combustion tubes in the research analytical laboratory where pure oxygen is brought in contact with the metal, at temperatures from 900 to 1000 deg. C. These are thus far operated all right and still appear unaltered after nearly 100 hours' use.

The above facts seem to indicate that this is a simple method for extending the use of iron under oxidizing conditions at high temperatures, and for greatly prolonging the life in those instances where it is now used but must be renewed at frequent intervals. In the case of small mufflers or crucibles, where temperatures are below 1000 deg. C., this treatment of cheap cast or wrought-iron shapes seems very promising. While the life of the coating depends on the temperature at which it is used, as well as on the duration of time taken in its preparation, i.e., the quantity of aluminium which

alloys with the surface of the iron, it does not permit of long use at temperatures much in excess of 1100 deg. C.

Copper parts also, which are exposed to high temperature, can have their life increased by calorizing. In some cases calorized copper may be used advantageously in place of aluminium bronze. For instance, a large power station had trouble from early corrosion of its condenser tubes. These tubes were aluminium bronze and were supposed to last at least a year. As a matter of fact, while occasionally tubes would last as long as six years, other tubes would fail in four to six weeks after they had been installed. About two and a half years ago a set of calorized copper tubes was installed and so far not a tube has failed.

In some cases the life of copper contacts can be increased by calorizing. For instance, a set of railway controller contacts which were calorized showed double the life of the ordinary untreated contacts.

As has been said, the effect of calorizing is to produce a surface alloy containing aluminium. The thickness of this alloy varies with the length of time during which the piece is subjected to the calorizing process, and the percentage of aluminium varies through the coating, being greatest at the surface. This is shown clearly by a cross-section of a calorized copper rod. The line between the alloy and the unchanged copper is sharp, but the color of the alloy varies from a rich golden-yellow next to the copper to a silvery-white at the surface.

When an iron pipe or ribbon is calorized for a heating unit, a portion of the iron becomes alloyed with the aluminium. Naturally this results in changing both the resistance and the temperature coefficient. The thicker the calorizing coat the greater is the change. This is shown by Table I, in which No. 1 was given a lighter coat than No. 2.

TABLE I

Sample	Ohms per M (19°)	Temp. Co-Ef. Elec. Resis. (0—150°) × 10 <sup>-4</sup>
Iron ribbon	0.905	5.61
Same calorized, No. 1	2.45	1.72
Same calorized, No. 2	7.6	0.151

A thin ribbon may easily be calorized all the way through, and then becomes quite brittle.

The dimensions and weight of either a copper or iron piece are slightly increased by calorizing. The increase of dimension is much less than the thickness of the alloy coat, the greater part of which simply takes the place of the original metal. The dimensions may, however, increase several mils and there is a tendency to a greater increase at the edges than on flat surfaces.

For iron, calorizing is intended only for protection at high temperatures. It does not compete with galvanizing, sherardizing, and other similar processes for protection against oxidation or corrosion at low temperatures. Its usefulness lies within a range of temperature much higher than a galvanized or sherardized coat could stand.

For copper, calorizing is effective against corrosion at low temperature as well as against oxidation at high temperature. The upper limit is determined by the melting point of the alloy, which is somewhat lower the heavier the calorizing treatment, since that means an alloy with a higher aluminium content.

The probable explanation of the effect of the aluminium in the surface alloy is that a thin coat of alumina forms which prevents further burning of the metal beneath. It is well known that a pure aluminium wire may be heated in the air to a temperature several hundred degrees above its melting-point, without flowing, when the thin alumina shell which surrounds and supports the molten metal is easily seen.

The original article in the *General Electric Review* contains some interesting microphotographs.

## Present Status of the Fink Furnace

BY H. B. PULSIFER

The Fink furnace has now been before the public in various ways for some years. In view of the fact that no large commercial units are operating, while the Fink Smelters Company yet claims to have a valuable addition to metallurgical equipment, this contribution is offered as recording some of the difficulties encountered in trying to improve metallurgical practice and get more value from some ores and some value from ores as yet practically worthless.

### Patents

The Fink furnace is presented by men who are not at present engaged in the smelting industry; that is, they have no works of their own in which the furnace could be placed and put to work as a matter of regular routine. A very large amount of money has been expended on the evolution of the furnace and its operation, so that to secure the investment and legitimate profit every detail possible has been patented. The securing of domestic and foreign patents has consumed much valuable time and delayed matters at several times when otherwise much progress might have been made.

Patents on metallurgical devices are being issued these days and upheld years after they have been applied for; the Fink sponsors have not seen fit to attempt other than the most open and conservative business policy. The matter of foreign patents has more than once caused delay; at this very moment accessory equipment promising increased usefulness to the furnace proper awaits patent issues in countries so disturbed by the war that business and communication are paralyzed. Whether or not obtaining patents be accepted as the best possible course, the Fink company has chosen this course and has experienced this trouble.

### Suitable Raw Material

The ideas of the peculiar field for a furnace of this type have considerably changed since the early days of Mr. Fink's efforts at smelting copper concentrates. It is realized that the type of furnace is hardly adapted to compete with the regular methods employing large units for smelting copper ores. On the other hand, it has become more and more evident that the furnace has a special field in that it can assimilate a mixed sulphide ore and separate it into three parts, two of which are valuable while the third is barren and holds the undesirable constituents of the original ore. It is the method of treatment which produces a volatile, condensable portion containing zinc and lead; a matte or metal containing copper and precious metals, and a slag of customary composition devoid of appreciable value.

With the growth of the idea that the furnace could not compete with larger units on simple ores the aim has been to place furnaces where their success would be pronounced and permanent.

Available ore-deposits and abundant raw material have not lacked from this point of view. The countries of the globe are profusely supplied with ores which are going begging at the present time. Great deposits of metal-bearing materials, the individual metals of which would be worth from \$20 to \$100 per ton of raw dirt, are idle or awaiting the proper treatment method. Other ores are today sold in great quantities for small fractions of their metallic values because one metal is thrown away to get another, or separation is extravagantly costly.

The Fink company has not been in a position to acquire any of these numerous deposits, exploit the mine, build the plant, smelt the ore and enter the metal-selling field. Such operations demand almost unlimited capital, besides several varieties of managerial re-

sources; the company has appreciated this phase and refrained.

### Sympathetic Hands

With this plethora of raw material available it is not difficult to imagine that numerous companies would be only too glad to take over and use the process; such is the case. Numerous concerns are only awaiting the opportunity to make the effort and reap the benefit. A review of such cases, or the ease with which sufficient capital may be acquired, wonderfully enhances one's already vigorous conception of the greed of man. The Fink company wants to control the furnace sufficiently to insure its future and get a fair proportion of any profits.

Metallurgists are only too well aware of the difficulty in introducing new equipment and getting it treated in proper manner; many a fine invention is thrown down and out by some brute, for some minor defect, through

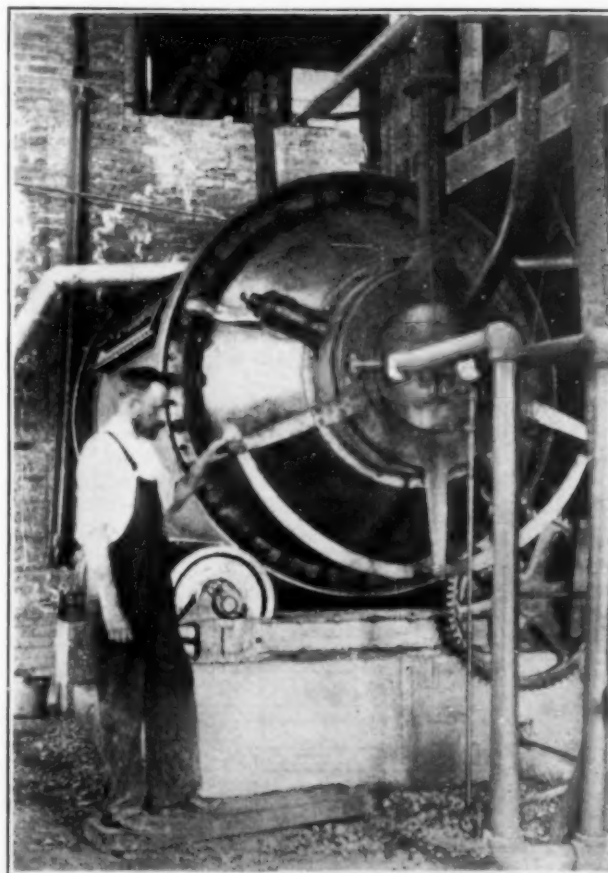


FIG. 1—FINK FURNACE IN OPERATION

prejudice; the most perfect machine or beautiful process usually requires patient and sympathetic coaxing until its operation is perfect and its intended operators learn that they are to accept it and keep it in shape.

On this basis many opportunities have not been considered where it was obvious that merely perfunctory attention could be expected. The Fink company does not intend to place any of its equipment in irresponsible hands.

### Plants Contracted For

About a year ago the Fink company entered into contract with the owners of the Teziutlan Copper Co., mines and plant in Puebla, Mexico, with every promise of seeing several of the Fink furnaces in prompt use under desirable conditions. Shortly after preparations were started the plant was forced to close down by war conditions; from that time the plant has been idle and no work possible.

During April, 1914, contract was made with the Mond Nickel Co., plant at Coniston, Ontario; furnace was shipped and installed and dried out for firing up. Almost on the minute of charging, cables closed the entire plant due to England's entering the war in this last August.

With both of these companies the contracts were desirable, the raw material abundant and competent technical staff on hand to insure a fair trial for commercial success.

Negotiations are at present under way with yet other companies and it is hoped that before long adequate trial of the furnace will be made to demonstrate its usefulness or otherwise. No runs sufficiently long to demonstrate working costs, life of lining or routine recovery have taken place as yet. Numerous trial runs have led the owners to believe that their confidence in the usefulness of the furnace is not misplaced.

#### A Recent Trial Run

The experimental furnace is situated at Wauwatosa, Wisconsin; unfortunately no adequate provision is made for collecting the fume. The following quotations from a report made on a run during August indicate the work the furnace can do.

"The Fink furnace is specially designed for the direct smelting of sulphide ores, being a converter-type furnace, using with equal facility either oil (crude or fuel), gas (natural or producer), or soft coal for fuel.

"It has three or more sets of tuyeres as seen in the accompanying drawing. These are spaced so as to leave at least one position of the furnace in which all of the tuyeres will be found above the tap-hole. This is very essential, for in smelting an ore of the mixed type it

mences immediately. When the carrying capacity of the furnace has been reached, the reduction is continued until the desired elimination of the zinc and lead have been obtained. The desulphurization of the zinc is not brought about entirely through the action of the tuyeres, as the low-pressure air supplied to the furnace for the combustion of the fuel also plays an important part in the oxidation. Whenever the tuyeres pass underneath the charge a fine spray of molten ore and matte is thrown up against the walls of the furnace. This spray, when it meets the stream of low-pressure air supplied from the end of the furnace, is in an ideal physical condition for rapid oxidation.

"The lead is driven off almost as fast as the ore is melted. However, the zinc requires more time for its elimination. As the sulphur continues to grow less in the charge, it is necessary to supply more fuel, as the tuyeres are no longer operating at full efficiency. It is now desirable to supply additional sulphide ore, free from zinc, if possible, to restore the activity of the tuyeres and to bring about the removal of the remaining zinc.

"While the air supplied through the tuyeres is primarily for the purpose of oxidizing the sulphides in the charge, it also materially assists in driving off the lead and zinc. This action is purely physical and wholly apart from the oxidizing effect of the air, and may be compared, in its effect, to the increased volatilization noticed when passing an inert gas over molten metal.

#### Analysis of the Ore

"We have used the analysis made by us as the basis of all of our calculations. Where 'Not determined' we have substituted their figures.

All calculations are based on the short ton of 2000 lb.

#### Method of Treatment

"The method of treatment proposed for handling this ore contemplates its smelting in the Fink furnace for the purpose of eliminating, by volatilization, the lead and zinc together with a portion of the silver contained, and the recovery in the matte of the copper, cobalt and gold together with the remaining silver.

The volatilized metals, which are largely in the form of sulphates and oxides, are collected for separation and further treatment.

#### Furnace Performance

"In all, 9000 lb. of the ore in question was received. Of this amount 8000 lb. was taken for treatment.

"The material for trial analyzed as follows:

	Analysis by Owners	Analysis by Fink Smelters Co.
Lead .....	22.54%	22.38%
Arsenic .....	.08	Not determined
Copper .....	.20	Trace
Zinc .....	33.29	33.48
Iron .....	3.77	4.60
Alumina .....	3.36	3.48
Silica .....	9.83	9.46
Sulphur .....	24.74	25.10
Cobalt .....	.87	.78
Magnesia .....	.25	Not determined
Lime .....	.17	Not determined
Silver (long ton) .....	18.7 oz.	(short ton) 16.7 oz.
Gold .....	Trace	Not determined

"The run was made on Thursday, Aug. 27, 1914, beginning at 8 o'clock a. m. with a cold furnace. The run

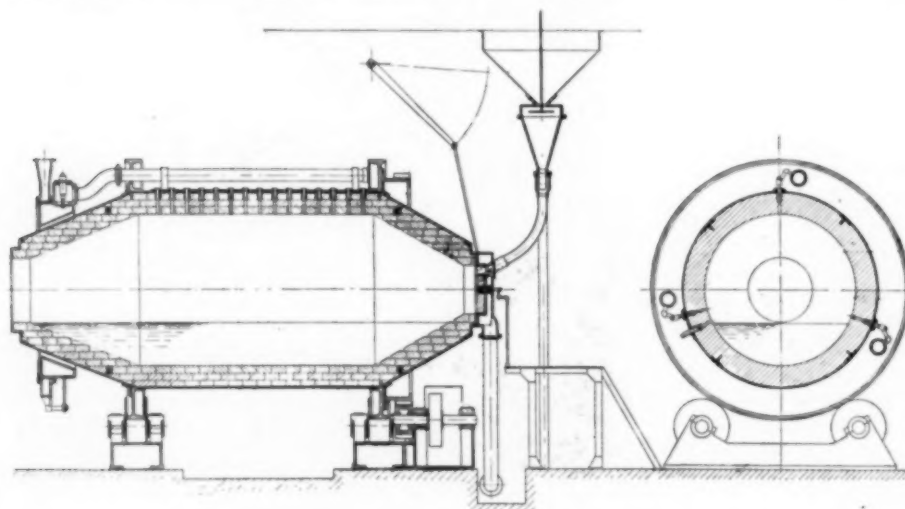


FIG 2—FINK SMELTING FURNACE

often becomes necessary to use the furnace for a time as a reverberatory, and this can be accomplished by simply bringing the tuyeres above the charge, shutting off the high-pressure air, and continuing the oil in order to heat the furnace. The opening and closing of the tuyeres is regulated by means of a cam, and only when any particular set of tuyeres is passing underneath the charge is the full air supply permitted to enter this tuyere box.

"The ore is fed, either continuously or intermittently, through a feed pipe which fits into a stationary door, containing also openings for the introduction of the burner nozzle as well as for the supply of additional air. The waste gases and fumes pass out at the opposite end.

"After the furnace is once brought to a smelting heat, the ore is fed, and rapid desulphurization com-

ended at 9:20 in the evening with the tapping of the slag.

"Crude oil, pre-heated, at a pressure of about 60 lb., was supplied through a spray nozzle. The air pressure as supplied through the tuyeres varied from 5 to 7 lb. and the blower delivered approximately 600 cu. ft. per minute.

"At 11:30 a. m. the furnace was at a red heat and 500 lb. of ore was charged. At noon 500 lb. was added, and 1000 lb. between 12:15 and 12:45. At 1:20 a ton was fed into the furnace; another ton was added at 2:15 and the fourth and last ton at 3:10.

"At 6 p. m. 50 lb. of coal was added and at 6:30, 100 lb. more; the furnace heat increased and zinc elimination was strong. At 8:40 35 lb. of coal was added and blowing continued until at 9:20 the slag was tapped and the run ended.

"The total amount of oil consumed during the run was 132 gal., equivalent to 33 gal. per ton of ore smelted. When it is considered that the proper smelting temperature was not attained until toward the end of the operation it is obvious that most of the oil was used in heating the furnace and not in smelting the ore. Much less would be required per ton in continuous smelting.

#### Recoveries

"The slag amounted to 1780 lbs.; it analyzed:

Zinc .....	14.5%
Lead .....	0.5
Silver .....	16. oz.

Some of the fume analyzed:

Zinc .....	24.5%
Lead .....	34.6
Silver .....	15. oz.

"The original ore contained 33.48 per cent zinc, or a total of 2678.4 lb. in the ore charged; and the slag contained only 14.5 per cent zinc, or 258 lb.; hence 2420 lb. of zinc was eliminated during the run, which is equivalent to a trifle over 90 per cent of the total.

"The original ore also showed 22.38 per cent lead, or a total of 1790.4 lb. in the ore charged, and the slag contained 0.5 per cent lead, or 8.9 lb. The elimination of the lead was almost perfect.

"That portion of the slag carrying the matte was separately assayed for silver and showed 18 oz. per ton. Since the original ore carries 16.7 oz. silver per ton, or a total of 66.8 oz. for the four tons treated, and the 1780 lb. of slag carried about 16 oz. of silver per ton, it is evident that about 78.6 per cent of the silver had been volatilized with the lead and zinc.

"Owing to the lack of iron in the ore, the addition of sulphides is doubly necessary to form a slag sufficiently liquid to allow of its thorough separation from the matte. At the time of making this test sulphide ore was not available, and this forms the only unsatisfactory feature of the run.

"In case it is not possible to obtain pyrite ore or concentrate to add to the furnace before tapping the charge, it will be necessary to add limestone at the commencement of the operation, so as to assure the production of a more liquid slag, whereby a better separation of the matte and silver will be obtained.

#### Collection of Fume

"Substantially all of the volatilized zinc, lead, and silver which are eliminated from the furnace in the smelting operation are positively collectable as fume or concentrate in the standard form of bag-house now widely used for that purpose.

"The cost of the regular blast-furnace plants for recovering the zinc, lead and silver products in the bag-house, where a *minimum* of fume is produced, cannot be applied to our particular case where the reverse is

true, for we produce a *maximum* of fume and recover a correspondingly greater amount of product; hence our cost for this recovery per ton of product is much less.

"It is safe to say that \$1 is a high estimate of the cost of recovering a ton of fume produced from the Fink furnace, which would represent for this mixed type of ore about 70 cents per ton of charge treated. In a large installation this cost could undoubtedly be materially reduced.

"The bag-house product in the case of this ore would be an impure zinc oxide, mixed with lead sulphate, and carrying that part of the silver that has not been taken up by the matte in the furnace, or contained in the slag, and would be of a somewhat different composition to that of the product secured in this particular run, inasmuch as the zinc and silver being lighter when passed directly through the stack did not condense as rapidly as the heavier lead sulphate.

#### Costs

"As to the costs of the smelting operation, it may be stated in general that this is largely governed by local conditions. If oil may be had for 3 cents per gallon, the fuel item for smelting purposes alone would not exceed 60 cents per ton of charge.

"The attendance is about the same as that required for handling the ordinary basic converter, and three men on a shift would be more than ample to serve a 100-ton furnace. As the ore-feed is automatic, the sole labor, aside from the preliminary handling of the ore, consists in tapping the furnace, oiling the machinery, and collecting the recovered products.

"The following, by way of a summary, is an approximate estimate (exclusive of interest, depreciation and overhead) of the cost per ton of smelting the mixed ore in the Fink furnace, based on a daily capacity of 100 tons, beginning with the crushing of the ore to 2-in. size, and ending with the elimination of the volatile products from the furnace, and the recovery of the copper-cobalt matte carrying the gold and that portion of the silver not taken over with the fume or carried in the slag:

	Cost per Ton
Crushing .....	\$0.05
Electric power, including machine shop, lighting, etc., at \$40 per hp per year .....	.55
Labor—3 shifts of 1 furnace tender at \$3.50 and 1 laborer at \$2.50; 2 shifts, 1 engineer at \$3.50; total \$25 per 24 hours .....	.25
Superintendent at \$3,600 and clerk hire at \$1,200, \$4,800 per year .....	.13
Oil, 20 gallons at 3 cts. ....	.60
Total .....	\$1.58

Whether we agree with the Fink company in regard to its costs, or not, and whatever view we may take of the ease or difficulty of turning the fume into commercial products, we have to admit that in this case a raw ore of the most refractory nature has been broken up and put a long way on its course to complete usefulness without any flux. This particular ore has a homogeneous steel-gray appearance and is absolutely beyond physical separation. It is undesired by either lead or zinc smelter and has almost no commercial value. Should the actual operating costs come anywhere near the estimates, the furnace is of remarkable promise.

Chicago, Ill.

The new concentrating mill of the Daly West Mining Co., at Park City, Utah, was expected to be ready for operation about October 15.

The Werner & Pfleiderer Company, the well-known makers of machinery for the chemical industry, are increasing their manufacturing facilities by the addition of an up-to-date extension to their foundry at their factory in Saginaw, Mich.

### Gas-Blowing Engines

The Mesta Machine Company of Pittsburgh, Pa., are now building for the Pennsylvania Steel Company of Steelton, Pa., two gas-blowing engines of 46-in. and 84-in. cylinder diameters and 60-in. stroke. These engines are believed to be the largest gas-blowing engines ever built in the United States or on the American continent.

The gas cylinders and blowing cylinder are arranged in tandem; that is to say, the air cylinder is directly back of the gas cylinder. This arrangement has never been used in the United States but has been universally adopted by European gas engine builders. Undoubtedly this arrangement makes possible a much simpler design of the whole engines.

Another innovation as far as American gas engines are concerned is the use of a center crank instead of an overhung crank. While it is possible to build large engines with overhung cranks, it is considered that the center crank provides a more rigid construction; all of their large reversing engines have been built with center cranks and have been universally successful.

Finally, the blowing tub is equipped with the well known Mesta automatic plate valve (Iversen patent) which, since its introduction in 1911, has been a complete success. With these valves the efficiency of the air end is greatly increased and the cost of maintenance and repairs reduced to practically nothing, as all complicated valve gear is eliminated.

### Rapid Cyanidation of Ores

The American Rapid Cyaniding Company of Detroit, Mich., reports that they have installed a Reinohl rapid cyaniding apparatus at the Suffolk Mill, Ophir, San Miguel County, Colorado, operated by the Ophir Gold Mines, Milling and Power Company, Mr. George B. Pickett, vice-president and general manager.

Ore is run from a bin through crushers, then to a stamp mill, where it is further crushed in a cyanide solution, and conducted through a tube mill and reduced to about two hundred mesh. The pulp is then delivered to a Reinohl apparatus, comprising a launder and lixiviator, where the pulp is heated, additional cyanide supplied progressively to maintain its strength, and the pulp continuously agitated in the presence of the oxygen of the atmosphere, until contact is formed between the values and the solution.

From the end of the lixiviator the pulp is conducted to settling tanks, clarified solution bearing the values decanted, filtered and conducted through zinc shaving boxes in the usual manner. A complete cycle, from the ore bins, through the stamps, the tube mills, the Reinohl launder and lixiviator to a settling tank, clarified solution decanted from another settling tank, passed through a filter, into and through the zinc boxes, and the solution returned to the stock tank, was made in eleven minutes. Previous practice, by other cyaniding processes, required four days to accomplish the same result.

Recoveries indicated 96 per cent of the gold and 98 per cent of the silver in the ores, at a loss of 5 per cent of the strength of the solution.

Demonstrations of the process and apparatus were in charge of A. J. Weinig, engineer metallurgist of the Liberty Bell Mining and Milling Company, Telluride, Colorado, and Mr. Walter L. Reid, cyaniding engineer of the Smuggler Union Mill, Telluride, witnessed the plant in operation. The inventor, D. C. Reinohl, of Washington, D. C., superintended the installation of the apparatus, assisted by David W. Reinohl and Wesley B. Sibley.

### Obituary

**Curtis E. Whittlesey**, for many years treasurer and secretary of the McGraw Publishing Company, Inc., died at his home in Madison, N. J., on Friday, Oct. 9, 1914, in his seventy-second year. Though he had been ill of pneumonia for several days, the end came suddenly.

Mr. Whittlesey was born near Rochester in 1842. As a young man he entered business in Corfu, N. Y., where his industry and capacity brought him early success. In 1890 he joined James H. McGraw as a member of the firm which was the publisher at that time of the *Street Railway Journal*, and which, as the present McGraw Publishing Company, Inc., became also the publisher of the *Electrical World*, *Engineering Record*, and *METALLURGICAL AND CHEMICAL ENGINEERING*. Mr. Whittlesey had also been the treasurer of the Electrochemical Publishing Company, the former publisher of *METALLURGICAL AND CHEMICAL ENGINEERING*, from its early days as *Electrochemical Industry*. He was a wise counselor, conservative in his fundamental principles on the ideals of technical journalism, yet progressive in the deep personal interest which he took in the career of this journal and its ever broadening editorial scope and influence. All the members of the staff of this journal are indebted to him for innumerable kind words and acts of sympathy, advice, and encouragement.

During the twenty-four years of association with the McGraw Publishing Company Mr. Whittlesey had become widely known as a man of great experience in business affairs, and his wisdom and unerring judgment were constantly consulted not only in the affairs of the company, which he had done so much successfully to establish, but by many individuals who had come thoroughly to value his opinions on commercial and financial questions. Although his passing came with the ripeness of years, it is deeply lamented by a host of friends, many of them close business associates, who loved and honored him. It was impossible to have even the most cursory relationship with him without being impressed by his lovable qualities and sterling character.

Mr. Whittlesey was keenly interested in church work, and was for years an elder and the treasurer of the Presbyterian Church at Madison, N. J.

He leaves a widow and three daughters, Mrs. Carl A. Felt, wife of the Rev. Carl A. Felt, of the Pekin University, China; Mrs. James H. McGraw, wife of the president of the McGraw Publishing Company, Inc., and Mrs. Robert E. Harned, wife of the Rev. Robert E. Harned, librarian of the Drew Theological Seminary, Madison, N. J.

\* \* \*

**Thomas Johnston Grier**, superintendent of the Homestake Mining Co., died on the evening of September 22, 1914, at Los Angeles, Cal., where he had been with members of his family for several weeks. Although his intimate friends and associates knew that his heart was weak and that his passing would be sudden, nevertheless the news of his death came unexpectedly.

Mr. Grier was born in Pakenham, Ontario, in 1850, being the fourth of a family of ten children. He received his education in the graded and high schools of Iroquois, Ontario, and at the age of 17 learned telegraphy and was employed as an operator at Montreal. Later he removed to Corinne, Utah, and again to Salt Lake City, where he continued in the same line of work. In 1878 he entered the employ of the Homestake Mining Company at Lead, S. D., in the capacity of a telegrapher and clerk. He gradually assumed increased responsibility, and at various times was in full charge of oper-

ations during the absence of Mr. Samuel McMaster, who was then superintendent. On the death of Mr. McMaster in 1884, Mr. Grier was appointed superintendent and held that position for thirty years.

In 1886 he was married to Mary Jane Palethorpe, of Glasgow, Scotland. He is survived by his widow, a daughter and three sons.

His rise to the place of one of the foremost figures in America mining and metallurgy was from humble beginnings, and practically without that specific preliminary training which might be considered necessary. The record of his work, however, shows native ability of an unusual order in the conception and execution of large undertakings. It shows also his appreciation of, and consideration for, the human element in business, for he was always mindful of the interest and condition of his employees and made many contributions to their welfare.

It was during his term of office that the Homestake company developed into the prosperous organization that is so well known today. He directed and completed vast improvements, such as the water system that supplies the company's works, the town of Lead and several surrounding settlements. The hydroelectric power plant at Spearfish, the Ellison hoist, the Star and Amicus mills, the slime plant at Deadwood, and the viaduct connecting the mills with the company's railway system, all were completed under Mr. Grier's direction. During this period the extent of the company's operations increased greatly: the number of employees rose to about 2500 and the monthly pay roll to \$250,000; the quantity of ore mined and milled reached nearly 4500 tons per day, but the management remained under his sole direction and to his discretion was left the entire policy of the company.

A suggestion of Mr. Grier's broad interest in general affairs is found in his relations outside the Homestake Mining Company. He was president of the First National Bank of Lead, vice-president of the First National Bank of Deadwood, vice-president and director of the Wasp No. 2 Mining Company and president of the Hearst Mercantile Company. He was also a charter member of the Homestake Veteran's Association, belonged to several Masonic orders and the Benevolent Protective Order of Elks. In 1892 he was elected to membership in the American Institute of Mining Engineers.

The Homestake company's policy of improving the condition of its employees and looking to their welfare is a personal tribute to the man who was its operative head for thirty years. Mr. Grier was always accessible to any employee who sought advice or a sympathetic hearing on any matter. As one of his associates has said, "in addition to his great ability, he was quite the most lovable man it has ever been my good fortune to know." Among the institutions established by the company is the hospital, the service of which is free to employees and their dependents. An Aid Fund, to which employees contribute \$1 each per month, is supported by the company to the extent of \$1,000 per month. This fund provides benefits in case of accident, illness or death. Recreation Hall, erected by the company at a cost of \$300,000, affords a place of amusement and recreation for employees and contains the Hearst free library. Mr. Grier's interest in all these developments gave the company an enviable reputation for consideration of those who helped daily to make it one of the most famous mining organizations in the world.

In August last the Federal Commission on Industrial Relations held a hearing at Deadwood, at which Mr. Grier and others gave testimony. At the close of the hearing the chairman of the Commission made the following comment on Mr. Grier's remarks:

"You have here the most remarkable business organization that I have come across in the country. You have developed welfare features which are beyond anything that I know of, and they are given with a liberal hand. You have a high scale of wages, reasonable hours—very fair hours. There has been evidently great progress made in taking care of the employees in the hospital service, and you have taken care of the cost of living, have kept it down below what employees in other communities have been forced to pay. You have practically been able by your great strength here as a huge corporation, dominating the whole community, to look out for the welfare of your employees, and to bring in an admirable class of citizens. It seems also that you are influential in politics, that you secure a good class of officials, and that you have secured the enforcement of law, the reduction of immorality. It seems also that you make an effort to build up the religious life of the community and that your policy is broad and liberal in all respects. I take it also, that this policy depends solely upon your personality. Such inquiries as I have made here indicate that in all cases the stockholders leave all these matters to you personally, and that this broad policy has been carried out by you on your own initiative, and that you have felt that it was necessary, for the good of the community, the securing of a fine class of labor here, which you have undoubtedly done, that you should hold the reins pretty tight on this community."

Although the Homestake Mining Company has been a recognized power in the business life of Lead and the Black Hills, still under Mr. Grier's direction that power was used wisely for the benefit of the community and never for his own aggrandizement. Perhaps few men in his position would have developed the policies in which his faith was justified, but the light of his example may well serve for the guidance of others in similar positions.

### Personal

Mr. William R. Appleby, dean of the Minnesota School of Mines, recently visited the mining districts of British Columbia.

Mr. Robert S. Blair and Mr. Albert F. Nathan have entered into partnership under the firm name of Blair and Nathan with offices in the Liberty Tower at 55 Liberty Street, New York City. The firm will confine its practice to the soliciting and litigating of patents and trademarks. Mr. Delos G. Haynes will be associated with the firm.

Mr. H. A. Butz, for the past four years chief engineer of the Dominion Iron & Steel Company, Ltd., Sydney, Nova Scotia, Canada, has severed that connection owing to the company discontinuing for an indefinite period all construction work, due to the present war conditions, and he has made no definite plans for the future. He was formerly with the Garrett-Cromwell Engineering Company, Cleveland, Ohio.

Mr. H. M. Eastman has recently joined the technical staff of the National Radium Institute at Denver in the capacity of assistant superintendent. Mr. Alan Leighton is now a member of the laboratory force of the Bureau of Mines in Denver.

Mr. Warren R. Gillard has resigned as chemist of the Pittsburgh Testing Laboratory to accept a position as research chemist with the Pittsburgh Plate Glass Company.

Messrs. Gould, Free and Ash, chemical engineers, announce that Mr. Edward E. Free has retired from the firm and that the business is being continued by Mr. Ralph A. Gould and Mr. Charles S. Ash under the firm name of Gould and Ash, with offices as formerly in the Monadnock Building, San Francisco. Mr. Edward E. Free will be at the Department of Plant Physiology, John Hopkins University, Baltimore, Md.

Mr. J. W. H. Hamilton, of Hamilton & Hansell and the American Grondal Company, has recently returned to New York after about one year's traveling in Europe, where he supervised the installation of several Greenawalt sintering plants.

Mr. J. E. Johnson, Jr., lectured before the Franklin Institute on October 8 on the subject "Recent Developments in Cast Iron Manufacture."

Mr. Philip Nungesser, of the Nungesser Carbon & Battery Company, Cleveland, Ohio, recently cele-

brated his twenty-fifth anniversary in the dry cell business. On September 7, 1889, Mr. Nungesser sold the first dozen of his cells and got 75 cents a piece for them. At that time a few cells were sold a month. The present yearly output of dry cells in this country is estimated as 40,000,000 cells.

Mr. Charles F. Rand has resigned as president and director of the Consolidated Coppermines Company.

Mr. L. Selmi has accepted the position of chief chemist-metallurgist with the Otis Steel Company, Cleveland, Ohio.

### Digest of Electrochemical U. S. Patents

PRIOR TO 1903

*Arranged according to subject-matter and in chronological order.*

*Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.*

AQUEOUS BATH (ELECTROPLATING) *Continued*

607,646, July 19, 1898, Pascal Marino, of Paris, France.

Relates to depositing metals or alloys or to extracting metals from minerals containing them, by electrolysis in a mixed electrolyte. A solution is prepared, say, of one equivalent of that metallic salt to be deposited, selecting such salts as form insoluble precipitates with barium, strontium, calcium, or lead; and another solution of a salt of a different acid of barium, strontium, calcium, or lead, containing less than one equivalent of it. These two solutions are then mixed, and, in consequence of double decomposition, an insoluble precipitate is formed, and the remaining liquid is used as the electrolyte. In order to extract copper from a mineral the electrolyte is prepared with a solution of sulfate of copper. An alkali metal surface is added to it, and it is mixed with an insufficient quantity of chloride of an alkali-earth metal, so as not to precipitate the whole of the sulfuric acid combined with the copper and the alkali. There will be formed a sulfate of the alkali-earth metal, and the liquid, decanted or filtered, will contain only a mixture of sulfate and of chloride of copper, together with a sulfate and chloride of the alkali. To improve the conductivity and to facilitate decomposition of the mineral, I add a mineral acid, such as sulfuric or hydrochloric; the mineral containing the copper is used as an anode. When using metal anodes, a carbon anode is sometimes used with the metal.

610,954, Sept. 20, 1898, Eddy T. Thomas, of New York, N. Y., assignor to Harold Binney, trustee, of same place.

Relates to electroplating large objects, such as a ship, and consists in an open-sided tank having rubber packing edges, arranged to be temporarily secured to the object, such as a ship, the tank to contain the electrolyte. The iron body of the ship is cleaned, either mechanically or chemically, the tank secured, and an alkaline electrolyte containing a cyanide is used, since this makes a better deposit upon the iron. After the cyanide deposit, a sulfate of copper solution is used, to complete the deposit. The tank is next moved to an adjoining section and secured in a position that will produce overlapping deposits upon the ship. The anodes are removably suspended in the tank.

612,250, Oct. 11, 1898, Heinrich von der Linde, of Crefeld, Germany.

Relates to the removing of electrodeposited metal, such as nickel, copper, alloys of nickel and copper, etc., by connecting the plated metal as anode in an electrolyte of ammonium carbonate; the nickel and copper are dissolved and deposited upon a suitable cathode, the iron base of the anode not being affected by the electrolysis.

621,084, March 14, 1899, Henry L. Hollis, of Chicago, Ill.

Relates to coating iron articles such as sheets with a coating that will protect the article from rust. The article to be treated is connected as an anode in an alkaline electrolyte, such as sodium hydroxide, of specific gravity 1.25 to 1.40, temperature 50 deg. to 115 deg. C., and an anode current density of from 0.005 amp to 0.30 amp per sq. in. An iron cathode may be used, the current being interrupted when the coating is completed. The article so coated is then subjected to an annealing temperature of 800 deg. to 1400 deg. F., which changes the oxide to magnetic oxide and is so intimate with the iron that sheets may be bent without affecting the condition of the coating.

625,255, May 16, 1899, Thomas Archibald Goodchild and Archibald Campbell Tait Bond, of London, England.

Relates to the production of disappearing water-marks on manufactured paper. Upon a platinum sheet, constituting the anode, is placed moistened blotting paper or other absorbent material, and on this the paper to be marked, previously moistened through with ordinary water, for example, a water containing 20 gr. of saline matter per gallon answered the purpose. A platinum cathode of the desired design is now pressed firmly on the moistened paper for from five to ten seconds, according to the paper and strength of current. On removal of the cathode a distinct and translucent image of the design appears, which gradually fades away as the paper dries, and finally becomes invisible, but may be revived by moistening the paper. It is supposed the sodium hydroxide liberated at the cathode from the saline matter in the water acts upon the paper, the latter becoming more hygroscopic at the points of contact.

### Book Review

**The Mineral Industry**, its Statistics, Technology and Trade during 1913. Edited by G. A. Roush, A. B., M. S., Assistant Professor, Department of Metallurgy, Lehigh University; Assistant Secretary of the American Electrochemical Society. Octavo, 1010 pages, 55 illustrations. Price, \$10. New York: McGraw-Hill Book Company, Inc.

This is the twenty-second annual volume of the famous series founded by Richard P. Rothwell and continued by such well-known editors as Joseph Struthers and W. R. Ingalls. It is interesting to note in passing that the first editor was once professor of mining in Lehigh University, and that the present editor is also connected with the same institution.

The present volume fully lives up to the reputation of its predecessors. The note in the list of contributors many of the contributors to previous volumes, and also the addition of many new names which will lend added authority to its contents. Among these new names we notice L. Addicks on Electrolytic Copper Refining, H. Foster Bain on Potassium Salts, Dr. C. G. Fink on Tungsten, B. L. Miller on Graphite, T. T. Read on the Copper Hydrometallurgy, Dr. Weintraub on Boron.

The policy of the new editor has been one of consolidation of separate articles where possible under one generic heading; also to place the articles in the hands of specialists who can handle the material authoritatively, and express valuable opinions as well as compile statistical information. In succeeding volumes we may expect still further improvements of a similar nature; but taken as it is, we can judge the present volume as worthy of the best traditions of the "Mineral Industry," and a credit alike to the capacity of the contributors and the ability of the editor.